ROYAL
BOTANIC GARDENS
VICTORIA

Muelleria

Plant, Algal and Fungal Taxonomy and Systematics

Vol 34, 2015–2016

Plate LXVI.

***Microseris lanceolata* (Walp.) Sch.Bip. [as *Microseris forsteri* Hook.f.]**
Source: State Botanical Collection
Illustration: W.H. Fitch (1860)

Murnong or Yam Daisy (*Microseris walteri* Gand.) has long been recognised as an important food plant of Aboriginal people of southern Australia. The characteristic plump, annually replaced tubers were eaten raw or cooked. Other
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ROYAL BOTANIC GARDENS VICTORIA

A new species of *Podolepis* (Asteraceae: Gnaphalieae) from New South Wales

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Introduction

The genus *Podolepis* Labill. is generally regarded as polyphyletic (e.g. Short et al. 1989; Anderberg 1991; Konishi et al. 2000; Jeanes 2015) and in need of revision. The results of molecular work by Konishi et al. (2000) support the reinstatement of both *Panaetia* Cass. and *Siemssenia* Steetz at some level and the removal of *Podolepis kendallii* (F.Muell.) F.Muell. and *Podolepis georgei* Diels (the latter to *Schoenia ayersii* (F.Muell.) J.M.Black; see Wilson 1992). Although a few species are not represented in the data set used by Konishi et al. (2000), it is clear that *Podolepis* s. str. (the clade that includes the type species, *P. rugata* Labill.) includes those species in which the limbs of the ray florets greatly exceed the involucre, and the individual involucral bracts have the claw and lamina discreet (i.e. attached only at the apex of the claw). Also included in this clade are *P. arachnoidea* (Hook.) Druce and *P. neglecta* G.L.Davis.

Podolepis s. str. consists currently of 18 species (Jeanes 2015) confined to Australia and found in all States as well as the Northern Territory and the Australian Capital Territory. For a detailed taxonomic and nomenclatural history of *Podolepis* and for an evaluation of the characters used to distinguish taxa, see Davis (1957). It is clear from the work of Davis (1957) and subsequent taxonomic treatments (e.g. Henderson 1969; Beadle 1980; Cooke 1986; Stanley 1986; Everett 1992; Jeanes 1999, 2015), that the morphology of the intermediate involucral bracts is of importance in the delineation of species in *Podolepis*. This remains true in the present

Abstract

Podolepis omissa Jeanes, a new species endemic to north-eastern New South Wales and closely related to *P. neglecto* G.L.Davis, is described and illustrated. Its distribution, habitat and ecology are discussed.

Key words: taxonomy, morphology, diagnostic features, Asteraceae

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study, but other characters such as indumentum, leaf morphology and capitulum size and shape often also prove useful. Furthermore, some species are apparently habitat specific.

In a recent paper (Jeanes 2015) I redefined *Podolepis* s. str. using a combination of morphological and molecular data. While researching this paper the name *Podolepis* sp. Warrabah, *J.R. Hosking 1862*, NSW Herbarium (APNI 2014), came to my attention. After an initial consultation with my colleague J.R. Hosking and the subsequent examination of herbarium specimens, it became obvious that this was a discrete taxon previously confused with *P. neglecta* (Fig. 1). Some herbarium specimens were already segregated as *P.* sp. Warrabah (formally described below as *P. omissa* Jeanes), but most could still be found stored as *P. neglecta*, *P. jaceoides* (Sims) Voss or *Podolepis* indeterminate. *Podolepis omissa* is likely to be part of *Podolepis* s. str. based on the long limbs of its ray florets and on its apparent close relationship with *P. neglecta*.

Taxonomy

Podolepis omissa Jeanes, **sp. nov.**

Type: **NEW SOUTH WALES.** Warrabah National Park, 27.iv.2000, *J.R. Hosking 1862* (holotype, MEL 2131971! (Fig. 2), isotypes, TARCH 6097, CANB 539182!, NSW 447127, NE 72206).

Podolepis neglecta sensu G.M. Cunningham et al. (1981) *non* G.L. Davis.

Podolepis neglecta sensu J. Everett (1992) p.p,. non G.L. Davis.

Podolepis sp. Warrabah (*J.R. Hosking 1862*) NSW Herbarium sensu APNI (2014).

Illustrations: Everett (1992) page 264 (as *P. neglecta*); J.R. Hosking unpublished image (see Fig. 3 this paper).

Perennial herb 30–70(–130) cm tall. *Stems* 1–several, erect, often sparingly branched, variously woolly or glabrescent. *Leaves* covered sparsely to densely with flattened elongate to coiled, multicellular hairs, sometimes glabrescent, margins recurved to ±flat, entire; basal leaves several in a sparse rosette, oblanceolate, 5–10 cm long and 5–10 mm wide, petiolate, base amplexicaul, often withering early; cauline leaves alternate, sessile, stem-clasping, usually linear to linear-oblanceolate, mostly 1–10(–18) cm long and 2–10(–18) mm wide, apex acuminate. *Capitulescences* simple or paniculiform. *Peduncles* 1–10 cm long, with several scarious scale leaves below the involucre passing into the leafy stem. *Capitula* 1–several, hemispherical, mostly 10–20 mm diam., 10–12 mm long. *Involucral bracts* multiseriate, with slender linear claws, unequal (outermost shortest, intermediate longest); claw stiff, glandular, shiny, straw-coloured, with an elongate central depressed green section on the stereome, most prominent towards the apex; lamina scarious; intermediate bracts 5–8 mm long, claw c. 1 mm wide at the narrowest point, lamina ovate to triangular, to c. 3 mm wide, extending to c. 4 mm beyond apex of claw, base attenuate and continuous with upper margins of claw, apex acuminate. *Florets* bright yellow; ray florets female, 35–50, lamina linear, 10–20 mm long, 3(–4)-toothed, teeth to 2 mm long, to c. 1 mm wide; disc florets bisexual, c. 10 mm long, numerous. *Cypselas* c. 2 mm long, c. 1 mm wide, papillose; pappus bristles 15–30, barbellate, shortly connate at base, 6–8 mm long. (Fig. 4)

Selected specimens examined: **NEW SOUTH WALES.** Warrumbungle National Park, Wambelong Camp area. 15.v.1980, *J.H. Willis s.n.* (MEL 575040); Grounds of "Wagon Wheel" Motel, southern edge of Coonabarabran, 12.xii.1998, *B.J. Lepschi 4126 & J.R. Connors* (MEL 2253130, CANB 626730, NSW, US); 31 km SW of Uralla on the New England Highway, 4.ii.1996, *M. Ito 96002, T. Nishino & Y. Kito* (MEL 2030350, NSW, TI); Forbes region. 1.4 km from N entrance gate to Mandagery State Forest, E side of track, 14.xii.1990, *S.M. Prober s.n.* (CANB 00492321); 6 miles [9.7 km] north of Bundarra G.P.O. on Inverell road, 9.iii.1954, *R.W. Jessup & M. Gray 572* (CANB 97675); Burbie Creek, Warrumbungle Range, 29 km W of Coonabarabran, 6.xii.1973, *H. Streimonn s.n.* (CBG 53893, NSW); 18 km from Uralla on Kingstown road, 7.xii.1989, *D.L. Jones 5549 & C.H. Broers* (CBG 8914078); 14.4 km W of Baldersleigh, between Armidale and Bundarra, 28.xii.2008, *A.R. Bean 28415* (BRI AQ820428).

Distribution and habitat: Endemic to New South Wales where it is distributed in the Brigalow Belt South, Nandewar, New England Tablelands, NSW South Western Slopes and Sydney Basin Regions (sensu IBRA7, Commonwealth of Australia 2012). Reports of this species from the Hillston-Cobar, Enngonia and Paroo River areas of western New South Wales (Cunningham et al. 1981 as *Podolepis neglecta*) appear to be unsupported by voucher specimens and require further investigation. Found mostly on sandy soils, but also on skeletal soils in volcanic areas (J.R. Hosking pers.

cm
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150 -
TYPE
NATIONAL HERBARIUM OF VICTORIA (MEL), AUSTRALIA
MEL 222581
Podolepis neglecta G.L.Davis.
Noosa Heads Q... exposed situation among grasses on headland 28.8.1955. G.L.Davis
det.

Figure 1. Isotype of *Podolepis neglecta* (MEL 222581)

cm
0 1 2 3 4 5 6 7 8 9 10
copyright reserved
Royal Botanic Gardens Melbourne
National Herbarium of Victoria (MEL)
Podolepis omissa Jeanes
HOLOTYPE
Determinavit J.A. Jeanes 31/7/2014
MEL 2131971
TAMWORTH AGRICULTURAL RESEARCH CENTRE
HERBARIUM (TARCH)
Family: Asteraceae
Podolepis sp. aff. neglecta
Det.: JRH
Loc. Warrabah National Park
NSW Subdivision: NWS
Lat. 30° 34' 02"S Long. 150° 54' 46"E, Alt. 590 m
Coll. J. R. Hosking 1862, T. L. & G. R. Hosking - Date 27 April 2000
Notes Scattered but common (many 1000s in Warrabah National Park) herb to 85 cm high. Few plants in flower at this time. Flowering stems annual, rosette at base perennial. Leaves glabrous and green above, slightly paler below and roughened, margins with a few hairs. Flower heads (including ligulate florets) to 3 cm wide. Involucral bracts green with tips angled out from head. Florets yellow. Ray florets ligulate, to 1.3 cm long, male; disc florets tubular with 5 lobes, bisexual.
Landform: 0–20° slopes
Substrate: New England adamellites
Soil: grey-brown loamy sand
Vegetation: growing in Callitris glaucophylla J. Thompson & L. A. S. Johnson and Eucalyptus spp. woodland
Identity confirmed by J. R. Hosking using NSW (main collection) on 21 June 2000.
Dupl. to: CANB MEL NSW NE
TARCH N° 6097
TYPE
NATIONAL HERBARIUM OF VICTORIA (MEL), AUSTRALIA

Figure 2. Holotype of *Podolepis omissa* (MEL 2131971)

Figure 3. Photograph of flowering capitulum of *Podolepis omissa* (courtesy John Hosking)

comm.) over basalt or granite substrates. Habitat varies from shrubland to grassy woodland under *Eucalyptus* L'Hér. (often *Eucalyptus microcarpa* (Maiden) Maiden or *Eucalyptus alba* Reinw. ex Blume) species or mixed *Eucalyptus/Callitris* Vent. species. (Fig. 5)

Conservation status: Reasonably common, widespread and represented in conservation reserves and thus neither endangered nor threatened.

Flowering period: Most months of the year, but most flowering herbarium specimens were collected in summer and autumn. Flowering is probably rain dependent.

Diagnostic notes: *Podolepis omissa* is readily distinguished from *P. neglecta* by its intermediate involucral bracts which are shorter and have laminas with acuminate rather than acute to obtuse apices. These distinctions were consistent and unambiguous in the many herbarium specimens examined during this study. The two species are apparently never sympatric and inhabit discrete biogeographical regions. The generally broader lower cauline leaves and slightly larger capitula of *P. neglecta* are also useful features for differentiating the two species, but may be due to the more mesic habitats and more nutrient-rich soils that *P. neglecta* frequents.

Etymology: From the Latin *omissa* = omitted, left out, disregarded or neglected. Until recently this species has been overlooked and included in *Podolepis neglecta*, itself a species overlooked for many years until its first description in 1957.

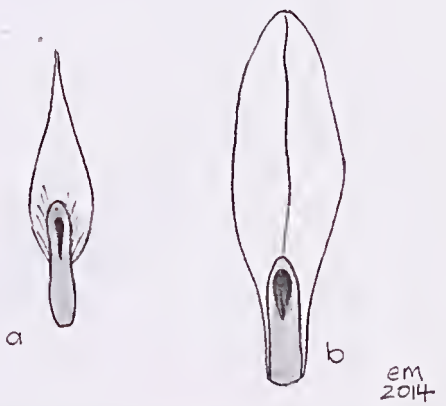

Figure 4. Intermediate involucral bracts ×5 **a.** *Podolepis omissa*; **b.** *P. neglecta*

Table 1. A summary of the diagnostic characters, habitat and distributional information of *P. omissa* and *P. neglecta*. Length and width measurements are abbreviated as L and W respectively.

	Podolepis omissa	*Podolepis neglecta*
Lower cauline leaf size	50–100(–180) mm L × 2–10(–18) mm W	50–200 mm L × 10–40 mm W
Capitulum diameter	10–20 mm	15–25 mm
Capitulum colour on drying	straw-coloured	golden brown
Claw of intermediate involucral bracts	with scarious margins in upper third	with scarious margins throughout
Lamina of intermediate involucral bracts	ovate to triangular	oblong
Intermediate involucral bract length	5–8 mm	9–12(–14) mm
Apex of intermediate involucral bract laminas	acuminate	acute to obtuse
Habitat	shrubland, dry Eucalyptus or mixed Eucalyptus/Callitris woodlands	wet sclerophyll forests and woodlands, rarely rainforest edges
Distribution	western slopes and plains of north-eastern New South Wales	tablelands and coastal areas of north-eastern New South Wales and south-eastern Queensland

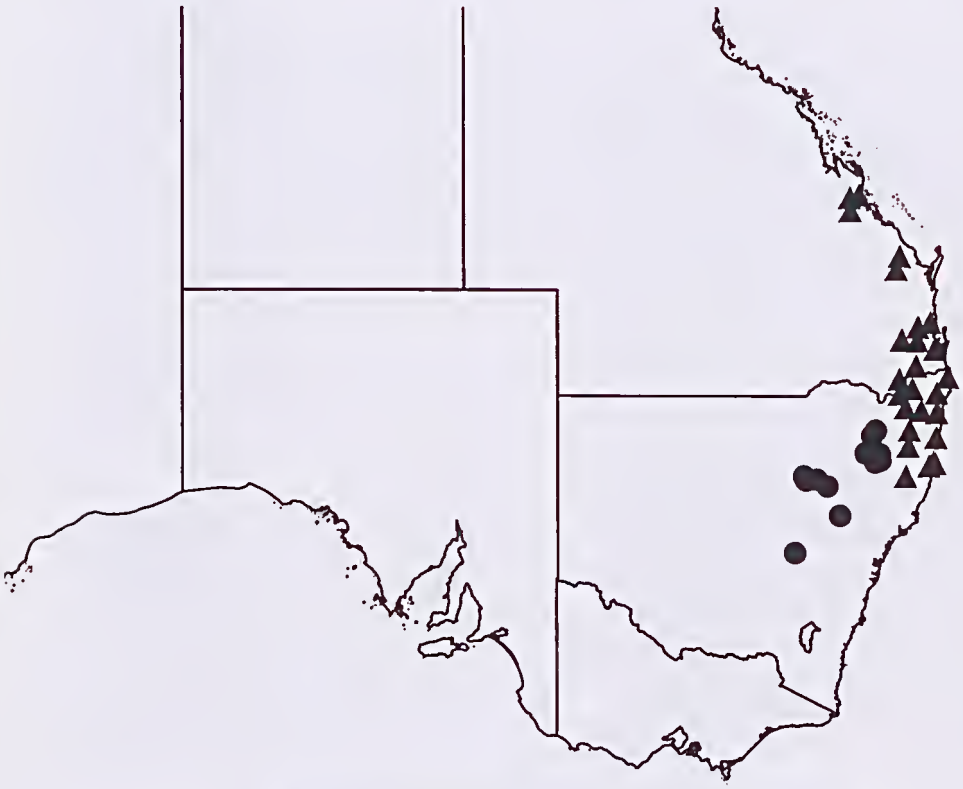

Figure 5. Distribution of *Podolepis omissa* (●) and *P. neglecta* (▲)

Acknowledgements

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Elevation of rank for *Leucochrysum albicans* var. *tricolor* (Asteraceae: Gnaphalieae)

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Introduction

Recent scrutiny of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Department of Environment 1999), has resulted in a surprising determination that taxa below the rank of subspecies 'are not considered to be species for the purpose of the EPBC Act and are not eligible to be listed under section 178 of the EPBC Act' (Department of Environment 2014). This clearly has implications for the conservation of a number of taxa currently listed at varietal rank under the Act. At the time of writing, there are 19 varieties included in the Threatened Flora List (Department of Environment, continually updated A) and the case for retaining these on the List is being assessed (e.g. Department of Environment, continually updated B).

Leucochrysum albicans var. *tricolor* (DC.) Paul G.Wilson is currently listed as an 'endangered' taxon under the EPBC Act (Department of Environment 1999), and there appears to be no argument as to whether the taxon is correctly assessed as 'endangered' under the criteria accepted by the Act (Department of Environment, continually updated B). In order to have the threatened status of the taxon continue to be recognised, there needs to be either a case made for the amendment or reinterpretation of the Act, which, however desirable, is likely to be a very protracted and perhaps fruitless exercise, or elevation of *L. albicans* var. *tricolor* to a higher rank.

Abstract

Taxonomic and legislative arguments are offered to justify the elevation of *Leucochrysum albicans* var. *tricolor* (DC.) Paul G.Wilson to the rank of subspecies.

Key words: EPBC Act, conservation, subspecies, varieties

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The distinction between the taxonomic ranks of variety and subspecies is unclear and there has been considerable discussion on how these ranks should be applied. The guiding document for the nomenclature of plants (McNeill et al. 2012), while indicating that recognition of both ranks is entirely admissible, offers no definition of the terms or indication as to how they should be applied. There has been argument that variety is the 'traditional' infraspecific rank and that subspecies is something of an afterthought offered as a way of drawing together more similar varieties from those regarded as more distant (Turner & Nesom 2000). Stuessy et al. (2014) regard this as the 'Eastern School' approach in the USA but appear not to embrace it with enthusiasm. More recently, the rank of subspecies has often been reserved for more or less morphologically distinct entities within a species where the difference between the entities is slight relative to those between existing species in the genus, but where there is little or no overlap in the geographical or ecological range of the entities, implying, if not necessitating, restricted (or nil) gene flow between the subspecies. This approach appears to be increasingly embraced by Australian botanists who draw a deliberate distinction between the ranks, and may use both within revisionary or monographical works (e.g. Orchard 1975 (*Haloragis* and related genera), 1986 (*Myriophyllum*); Walsh and Coates 1997 (*Pomaderris*); George 1999a (*Banksia*), 1999b (*Dryandra*); Duretto et al. 2013 (*Correa*)). Varietal rank may be used for weakly distinguishable entities for which a greater degree of sympatry or shared ecology is tolerated. The distinction, however, is imprecise and inconsistently applied. Often the distinction between varieties and subspecies has a historical basis, with certain taxonomic groups seeming to attract one infraspecific rank over the other (e.g. traditionally, grasses have been recognised infraspecifically as varieties, whereas taxonomists of more conspicuous plants, such as eucalypts, more commonly confer subspecific rank for 'trivial' entities). Given this lack of clarity and inconstant application of rank, Stuessy (2009) made the sensible recommendation that, for the maintenance of nomenclatural stability, unless there were compelling reasons to do otherwise, existing infraspecific classifications should be retained. It is interesting to note that the International Code for Zoological Nomenclature (Ride et al. 2012) accepts only 'subspecies' as a formal infraspecific rank and it is tempting to think that the rationale for the EPBC Act was developed from a zoological rather than a botanical perspective – a similar criticism has been made of earlier iterations of the risk assessments of the international standard 'IUCN Red List of threatened species' (IUCN 2012).

Discussion

A revision of the *Leucochrysum albicans* (A.Cunn.) Paul G.Wilson complex (Dennis & Walsh 2010) elevated what was then *L. albicans* subsp. *alpinum* (F.Muell.) Paul G.Wilson to the rank of species and simplified the taxonomy of *L. albicans* to just two varieties (var. *albicans* and var. *tricolor* (DC.) Paul G.Wilson), both of which existed prior to the revision. The decision to retain the rank of variety for the two taxa was made on the basis of there being only one measured morphological trait that could separate them, i.e. white rather than yellow involucral bracts in var. *tricolor*. Nonetheless, var. *tricolor* was retrieved as a clearly separated group in both methods of analysis of a morphological dataset of 14 informative characters.

The mapped geographic ranges of the two varieties in the study indicates little overlap at a large scale, and at a finer scale where both may occur in close proximity, the two entities are known to occupy quite different habitats. Variety *albicans* is typically a plant of dry open forest and woodland, principally on shallow soils derived from sediments or granite. Variety *tricolor* is virtually confined to grassland communities, and at least in south-western Victoria and Tasmania, primarily associated with cracking clay soils derived from basalt or dolerite. Variety *tricolor* differs further in dying down to a rootstock following fruiting (Sinclair 2010), whereas var. *albicans* is generally an evergreen perennial (pers. obs.). Indeed, the distinctness in morphology, ecology and geography could be argued to be sufficient to recognise the taxon as a species, but the study of Dennis and Walsh (2010) suggested that the degree of difference between vars. *albicans* and *tricolor* was at a lower level than that between the other members of the *L. albicans* complex. Following the same rationale, a conservative approach is adopted here to retain recognition at infraspecific rank. But, while counter to the reasonable suggestion of Stuessy (2009) noted above, the elevation of var. *tricolor* to the rank of subspecies is proposed, both to concur with common usage in Australia, and to allow whatever

protection that is currently offered to it under the EPBC Act to continue, rather than to risk losing protection of a threatened taxon through a plausibly unintentional quirk of legislation.

Taxonomy

Leucochrysum albicans subsp. ***tricolor*** (DC.) N.G.Walsh, **comb. et stat. nov.**

Helipterum incanum var. *tricolor* DC., *Prodr.* 6: 215 (1838); *Leucochrysum albicans* var. *tricolor* (DC.) Paul G.Wilson, *Nuytsia* 8(3): 443 (1992).

Type: **TASMANIA.** Van Diemen [Tasmania], *R.C. Gunn 108* (holo: G-DC), *fide* Wilson 1992.

Concluding remarks

While acceptance of the above reclassification of *Leucochrysum albicans* will at least retain protection under the EPBC Act for subsp. *tricolor*, the question remains about the appropriate rank for the remaining 18 taxa currently listed under the Act at varietal rank. At least some of these, e.g. *Correa lawrenceana* var. *genoensis* Paul G.Wilson, are recognised by botanists as deserving of higher rank and revisionary work in *Correa* is underway (G.W. Carr pers. comm.). Other listed varieties, unfamiliar to me, may similarly warrant elevation of rank and may retain (or regain) protection under the Act as a consequence of revision. Whatever the outcome of future work, the loss of protection under an act that seeks to protect biodiversity is regrettable at the very least, and would be considered by many to be absurd. Loss of protection through accidents of history or semantics around recognition of rank would be avoided by a sensible, minor reinterpretation of the EPBC Act and obviate a piecemeal approach, of which the current offering is admittedly an example.

Acknowledgements

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ROYAL BOTANIC GARDENS VICTORIA

Subspeciation in *Lachnagrostis adamsonii* (Poaceae)

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Introduction

The Victorian endemic grass, *Lachnagrostis adamsonii* (Vickery) S.W.L.Jacobs (syn. *Agrostis adamsonii* Vickery) was only known from a single 1853 collection, labelled 'Melbourne' and lodged at the Herbarium, Royal Botanic Gardens, Kew (K), until it was re-collected along with other wetland grasses in a small depression on a road verge near Glenthompson in 1987. This specimen was originally identified as *Lachnagrostis filiformis* (G.Forst) Trin., which it superficially resembles, but a positive determination as *L. adamsonii* was soon made when viewed under the microscope. The short, non-geniculate and near apically attached awn on the lemma, plus the glabrous nature of the lemma itself, were clear identifying features. At the time, searches through MEL failed to find any misidentified or indeterminate examples of the taxon.

Three years later, a further and larger population was found at Skipton (D. Frood 1990 pers comm), which initiated survey and monitoring programs as part of a recovery plan for the species under the auspices of the then Victorian Government Department of Natural Resources and Environment (currently part of the Department of Environment, Land, Water and Planning). In addition, various student projects (unpublished) into salt tolerance aspects of *L. adamsonii* were conducted at the University of Ballarat during the latter half of the 1990s. In recent

Abstract

Variation within *Lachnagrostis adamsanii* (Vickery) S.W.L.Jacobs is assessed and two new subspecies from the central region of the western Victorian Volcanic Plain are described: *L. adamsanii* subsp. *ampla* A.J.Br. from inundated, saline sites and *L. adamsonii* subsp. *limasa* A.J.Br. from slightly saline, moist lake beds and flats.

Key words: taxonomy, morphology, Adamson's Blown-grass

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years, during research on control of *L. filiformis* on Lake Burrumbeet and Lake Learmonth in western Victoria, plants were found that did not conform to *L. filiformis* but appeared more similar to *L. adamsonii* (Warnock 2009).

Lachnagrostis adamsonii is listed as 'Endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and as 'Threatened' under the *Victorian Flora and Fauna Guarantee Act 1988* (Murphy 2010).

Previous studies of morphology and molecular markers (Random Amplified Polymorphic DNA-fragments (RAPDs) and Amplified Fragment Length Polymorphisms (AFLPs) found significant variation within *L. adamsonii* (James & Brown 2000; Brown 2013). In recognition of this variation, the current paper introduces new infraspecific taxa within *L. adamsonii* based on examination of a wide series of collections across known sites.

Materials and methods

Following the rediscovery of *Lachnagrostis adamsonii* in 1987, extensive field surveys were conducted during 1993–1997 throughout western Victoria. Survey work was extended into the Wimmera River catchment during 2002–2004, as part of research on salt-tolerant native grasses for the Cooperative Research Council (CRC) for Plant-based Management of Dryland Salinity. Additional searches into south-east South Australia have also been made.

Plant growth in the field (Brown unpub.) and under nursery conditions (James & Brown 2000; Brown 2013) has been examined and, although not reported here, does contribute to comments made concerning distribution, growth habit and habitat. All field and nursery collections have been examined morphologically, with the results summarised as descriptions in the taxonomic section below.

Results and discussion

Survey work has resulted in the species being collected from about 80 sites across south-western Victoria but not extending into South Australia. It remains surprising that a species could be relatively widespread across a well-inhabited region and remain undiscovered for so long. One factor that may help to explain this phenomenon is that the grass has only ever been found on moist, saline soils and, as these are often of small extent, they are generally regarded by property owners and land managers as 'waste ground' and only supportive of 'weeds'. However, evidence for the ephemeral nature of the grass is also a factor in the species being overlooked. During the drought years of 2001–2009, all of the known populations were observed to be in decline (Murphy 2010) and many sites currently appear devoid of any plants of the species. In addition to the drying out of sites during the drought, the lack of water table movement resulted in the gradual decrease of surface soil salinity and allowed the invasion of exotic grasses, including *Holcus lanatus* L. and *Phalaris aquatica* L. An additional competitive stress has derived from the spread of the tall tussock grass, *Lophopyrum ponticum* (Podp.) A.Love into *Lachnagrostis adamsonii* habitat (Booth et al. 2009).

Morphological examination has revealed a number of traits not formerly recognised for the species, including hairs on the lemmas, spikelets to 4 mm long, lemma awns to 6 mm long and anthers to 1 mm long. Although these increased ranges in the nature and size of characters show no clear demarcation between populations at a broad geographic level, examination of varying combinations of morphological features in relation to habitat is suggestive of real genetic distinctions and differentiation through environmental adaptation. Therefore, two new subspecies are recognised and described below: *L. adamsonii* subsp. *ampla* A.J.Br. and *L. adamsonii* subsp. *limosa* A.J.Br.

There is support for recognition of infraspecific taxa within *L. adamsonii* from previous studies of molecular markers. Ordination of RAPD data (James & Brown 2000) and clustering of AFLP data (Brown 2013) across populations of *L. adamsonii* both yielded patterns that were largely consistent with the proposed taxonomic arrangement. For RAPDs, only subsp. *adamsonii* (five populations) and subsp. *ampla* (one population) were sampled, but there was clear separation of the five samples of the latter from the other 16 samples (which were more widely scattered in the ordination). For AFLPs, two samples (from the same population) of subsp. *ampla* and five samples (from three populations) of subsp. *limosa* each fell in separate clusters with high

Key to *Lachnagrostis adamsonii* subspecies

1 Lemma awn usually 3 mm long or less; spikelet usually 3.5 mm long or less; culm usually 1.5 mm wide or less; leaves usually 1 mm wide or less (plants of highly saline, short-term inundated sites) ..... ***L. adamsonii* subsp. *adamsonii***

1: Lemma awn usually greater than 3 mm long; spikelet usually 3.5 mm long or more; culm usually 1.5 mm wide or more; leaves usually 1 mm wide or more 2

2 Lemma awn less than 4.5 mm long, inserted at 60% of the lemma back or higher; anthers usually 0.7 mm long or more; leaves usually 1.5 mm wide or more; mature non-senesced inflorescence partly enclosed by leaf-sheath and semi-contracted (plants of saline, long-term inundated sites) ..... ***L. adamsonii* subsp. *ampla***

2: Lemma awn usually 4.5 mm long or more, inserted at less than 60% of the lemma back; anthers 0.7 mm long or less; leaves usually 1.5 mm wide or less; mature non-senesced inflorescence more or less exserted and spreading (plants of slightly saline sites) ..... ***L. adamsonii* subsp. *limosa***

statistical support, while the remaining five samples of subsp. *adamsonii* did not cluster together (albeit with low statistical support for some placements). Further analysis of a wider range of populations across an expanded set of molecular markers would be instructive, particularly in respect of variation within subsp. *adamsonii*. For the moment, the combination of morphological and molecular (RAPD, AFLP) data supports recognition of subspecies *ampla* and *limosa* as separate to the type subspecies.

Examination of individual plants within any one of almost all of the 80–odd known populations of *L. adamsonii* shows most to be of uniform morphology. Only in a handful of cases (Lake Goldsmith; Dashwood Station, Barunah; Corunnun, Lake Corangamite; Mt Weejort; and Mailmans Track, Skipton) is there some evidence of possible integration between the morphological types, described as subspecies below. Furthermore, nursery-grown plants have retained the characters of their populations, reinforcing the entrenched genetic differences between them. On the other hand, full species recognition in the face of some integration of characters is probably not justified.

Taxonomy

Lachnagrostis adamsonii (Vickery) S.W.L.Jacobs, *Telopea* 9: 445 (2001)

Agrostis adamsonii Vickery. *Contr. New South Wales Natl. Herb.* 1: 107 (1941).

Type: **VICTORIA.** 'Melbourne', *F.M. Adamson 226*, 12.xi.1853; holotype (K). [exact location unknown but, given its current distribution, is likely to have been a saline environment to the west of the City of Melbourne].

Caespitose or rarely shortly stoloniferous, glabrous, *annual* or *short-lived perennial*, to 90(–120) cm tall including inflorescences; culms erect to geniculate, 1–4 mm wide, usually unbranched, 4- or 5-noded; nodes glabrous, light brown and commonly hidden by leaf sheaths; internodes smooth or scabridulous; leaf sheaths often inflated at lower nodes and becoming loose from the culm above, striate, smooth or scabridulous between the nerves. *Leaf* blades dull green to bluish-green when fresh, shallowly grooved, involute (although basal leaves becoming flattened with senescence), smooth, sometimes scabridulous on exposed margins, up to 2 mm wide (unflattened), basal to mid culm leaf blades 10–50 cm long, upper culm leaf blades less than 10 cm long; ligules membranous, acute, becoming laciniate, (2–)4–6(–7) mm long. *Inflorescence* an open panicle, 15–25(–55) cm long and 15–25(–30) cm wide, becoming shortly exserted with maturity, peduncle and rachis retrorsely strigose to scabridulous, abscising at maturity; primary branches clustered (commonly 4–7 at lowest whorls), spreading, antrorsely scabridulous; secondary branching not occurring within at least the basal third of the length of lower branches; spikelets slightly overlapping towards the ultimate branch terminals. *Spikelets* 2.5–4 mm long, green to purplish-green; pedicel subclavate, scaberulous; rachilla extension present, 0.8–2.3 mm long including hairs; glumes not widely diverging, subequal or commonly the upper longer by up to 0.5 mm, scabrous on the keels, smooth on the lateral faces, entire to ciliolate on the upper margins; lemma 2–3.3 mm long, 5-nerved, entire or 2–4-toothed, callus with a dense tuft of hairs 0.5–0.7 mm long, back and/or laterals glabrous or with sparsely scattered hairs confined to the mid-third region, awned;

awn arising from upper half of lemma length, 1.2–6 mm long, straight, slightly curved or gently sinuate but never strongly geniculate; palea subequal to the lemma or shorter by up to 0.6 mm, shortly bifid; stamens 3, dehisced anthers (0.4–)0.5–1 mm long; caryopsis broadly ellipsoid giving the spikelet a distinct swollen appearance.

Common name: Adamson's Blown-grass.

Lachnagrostis adamsonii subsp. *adamsonii*

Annual or *short-lived perennial*; culms 1–1.5 mm wide, unbranched. *Leaf* blades usually 1 mm wide or less when unflattened. *Spikelets* 2.5–3.5(–3.7) mm long, green to purplish-green; rachilla extension 0.8–1.7(–2) mm long; lemma 2–2.5(–2.8) mm long, entire or toothed with minute setae to 0.2 mm long, back and laterals glabrous except for the callus, or with occasional to some hairs 0.3 mm long; awn arising from 65–95% of the lemma length from its base, 1.2–3(–3.3) mm long; dehisced anthers (0.4–)0.5–0.7 mm long. Fig. 1a–e.

Notes: The observation of scattered hairs on the backs of the lemmas in about half the populations of *Lachnagrostis adamsonii* subsp. *adamsonii* is contrary to the original description of the taxon, where the lemmas were stated to be glabrous (Vickery 1941). Apart from this feature, morphological characteristics of inflorescences and spikelets between glabrous- and hairy-lemma populations are not significantly different. Populations with hairs on the lemmas are more prevalent in the western part of the taxon's range while those with completely glabrous lemmas are most common in the east.

Only at Mailmans Track, Skipton, do some plants (approximately 20% of those measured) show spikelets slightly exceeding 3.5 mm length, lemmas slightly exceeding 2.5 mm length and awns slightly exceeding 3.0 mm, and, in these respects, they approach *L. adamsonii* subsp. *ampla*. However, these plants differ from subsp. *ampla* in having generally narrower culms and leaves, glabrous or near-glabrous lemmas and anthers 0.5–0.7 mm length. One collection at Mailmans Track (*A.J. Brown 2225*), growing in water in a roadside ditch, with spikelets to 4.3 mm length, hairy lemmas to 3.1 mm length, awns to 4.2 mm length, awn insertion of 65% of the lemma length and anthers of 1 mm length, conforms to subsp. *ampla*. The nearest known population of subsp. *ampla* to Mailmans Track is 8.5 km to the west, on the corner of Millers Road and the Glenelg Highway.

Distribution: Endemic to western Victoria between Portarlington on the Bellarine Peninsula in the east and around Cavendish to the west of the Grampians.

Habitat: Largely confined to areas with average annual rainfall of 500–700 mm, where it is only found on moderately to severely saline, ephemeral swamps, depressions and drainage lines, in association with a range of highly salt-tolerant grasses and forbs. Does not tolerate prolonged inundation. Rarely found in association with *Lachnagrostis adamsonii* subsp. *limosa*.

Selected specimens examined: **VICTORIA.** 7 km ESE of Glenthompson on the Glenelg Highway, 17.xi.1987, *A.J. Brown 332* (MEL); 6 km SW of Glenthompson on Van Renens Lane, 10.i.1994, *A.J. Brown 829* (AD, NSW, CANB, MEL); 3 km S of Skipton, Mailmans Track, 11.i.1994, *A.J. Brown 864* (MEL); Caramut on the Warrnambool-Caramut Rd just S of town, 7.xii.1995, *A.J. Brown 1013* (MEL); 3 km E of Beeac on the Mingawalla Rd, 7.xii.1995, *A.J. Brown 1017* (MEL); 7 km W of Wickliffe on Williamson's Rd, 7.xii.1995, *A.J. Brown 1023* (MEL); 5 km E of Willaura, Hopkins River flats on Delacombe Way, 21.xii.1995, *A.J. Brown 1103* (MEL); 4 km W of Barunah on the Cressy-Shelford Rd, on the Mia Mia Ck, 21.xii.1995, *A.J. Brown 1113* (MEL); 0.5 km E of Moorabool at Cowies Ck crossing of Warner's Rd, 4.i.1996, *A.J. Brown 1144* (MEL); 4 km W of Mount Mercer on the Mount Mercer-Dereel Rd, 4.i.1996, *A.J. Brown 1145* (MEL); 4 km N of Lismore, cnr of Linton and Graham Rds, 5.i.1996, *A.J. Brown 1147* (MEL); 5 km N of Bushy Ck on Yarrock Rd, 5.i.1996, *A.J. Brown 1151* (MEL); Lake Goldsmith off Skipton Rd, 6.xii.1996, *A.J. Brown 1188* (MEL); 1 km E of Melville Forest on the Cavendish-Coleraine Rd, 31.xii.1996, *A.J. Brown 1267* (MEL); 3 km N of Haddon on the Ross Ck-Haddon Rd, 10.xi.1997, *A.J. Brown 1326* (MEL); 6 km N of Bulart, 12.xii.1997, *A.J. Brown 1432* (MEL); Moyston-Great Western Rd, between Rhymney Reef and Rhymney, 11.xi.2003, *A.J. Brown 2337* (CANB, MEL); 2 km S of Warrak on the Buangor-Ben Nevis Rd, 20.xi.2003, *A.J. Brown 1776* (MEL); easement opposite Black Rock Rd, Breamlea, 23.ii.2004, *A.J. Brown 1729* (MEL); 1 km from Geelong Rd on Point Richards Rd, Portarlington, 17.i.2008, *A.J. Brown 1893* (MEL).

Lachnagrostis adamsonii subsp. *ampla* A.J.Br., **subsp. nov.**

Differs from subsp. *adamsonii* in its more robust culms and general growth and in its usually longer glumes, lemmas, awns and anthers.

Figure 1. *Lachnagrostis adamsonii* subsp. *adamsonii*: **a.** inflorescence ×0.3; **b.** floret (with lemma hairs) ×10; **c.** floret (glabrous lemma) ×10; **d.** anther ×10; **e.** spikelets ×5. *L. adamsonii* subsp. *ampla*: **f.** spikelet ×10; **g.** anther ×10; **h.** floret ×10. *L. adamsonii* subsp. *limosa*: **i.** floret (with hairs) ×10; **j.** floret (glabrous lemma) ×10; **k.** inflorescence ×0.3.

Type: **VICTORIA.** St. Marnocks Station, Eurambeen-Streatham Road, Crossroads; 4.i.1996, *A.J. Brown 1129*; holotype (MEL 2384083); isotypes (CANB, HO).

Short-lived perennial; culms 1.5–3 mm wide, occasionally branching at nodes in very mature plants. *Leaf* blades (1–)1.5–2 mm wide when unflattened. *Spikelets* (3.3–)3.5–4 mm long, greyish- to purplish-green; rachilla extension (1–)1.5–2.5 mm long; lemma 2.5–3.3 mm long, entire or toothed with minute setae to 0.3 mm long, back and/or lateral faces with few to some hairs 0.5 mm long; awn arising from 60–75% of the lemma length from its base, 3–4.4 mm long; dehisced anthers (0.6–)0.7–1 mm long. Fig.1f–h.

Notes: The inflorescences of subsp. *ampla* remain partly enclosed and contracted by the leaf sheaths until late maturity, when the lower leaf blades and sheaths have already senesced and much of the seed has fallen. Because of this, mid-season plants appear to have smaller inflorescences in relation to their culms. While mature specimens usually exceed 60 cm in overall height, it is not unusual for mid-season plants of subspecies. *adamsonii* and *limosa* to reach the same height, except they display a much higher proportion of inflorescence to leafy tussock, particularly as their panicles are more or less fully exserted and actively spreading at this time.

Some plants collected in saline waterholes in the Mt Weejort area have slightly smaller spikelets than typical for the subspecies but do conform in respect to lemma awn and anther length and general growth habit (e.g. culm and leaf width, partly enclosed inflorescences).

Distribution: Confined to a few sites in the central region of the Volcanic Plain in western Victoria.

Habitat: Growing in saline swamps and drainage lines that remain inundated or waterlogged over the majority of the summer.

Etymology: After the Latin for 'large'.

Selected specimens examined: **VICTORIA.** 9 km W of Skipton, cnr of Millers Rd and Glenelg Highway, 1.xii.1989, *A.J. Brown 454* (MEL) & 15.xii.1995, *A.J. Brown 1057* (MEL); 5 km ESE of Mt Weejort on Mt William Rd, 16.xi.1994, *A.J. Brown 947, 948, 951* (MEL) & 6.xii.1996, *A.J. Brown 1187* (MEL); St. Marnocks Station, Eurambeen-Streatham Road, Crossroads; 16.xi.1994, *A.J. Brown 949, 950* (MEL); 5 km N of Derrinallum on the Vite Vite Rd, 15.xii.1995, *A.J. Brown 1059* (MEL) & 13.i.2012, *A.J. Brown 2554* (MEL); 3 km S of Skipton, Mailmans Track, 28.xii.2001, *A.J. Brown 2225* (MEL).

Lachnagrostis adamsonii subsp. ***limosa*** A.J.Br., **subsp. nov.**

Differs from subsp. *adamsonii* in its longer glumes, lemmas and awns and from subsp. *ampla* in its longer awns and usually smaller anthers.

Type: **VICTORIA.** Lake Burrumbeet, off Lake Burrumbeet Park, Cassidys Road, Burrumbeet; 28.xi.2008, *A.J. Brown 2443*; holotype (MEL 2384084); isotypes (AD, NSW, CANB, HO).

Annual or short-lived perennial; culms 1.5–3 mm wide, usually unbranched. *Leaf* blades usually 1–1.5 mm wide when unflattened. *Spikelets* 3.5–4(–4.5) mm long, green to purplish-green; rachilla extension 1.3–2(–2.5) mm long; lemma (2.7–)3–3.3 mm long, toothed with small setae to 0.7 mm long, back and/or lateral faces glabrous, except for the callus, or with occasional to few hairs; awn arising from 50–60% of the lemma length from its base, 4.5–6 mm long; dehisced anthers 0.5–0.6(–0.7) mm long. Fig. 1i–k.

Notes: This subspecies grows in association with subsp. *adamsonii* along the Mia Mia Creek on Dashwood Station, Barunah. Here, it is less common than subsp. *adamsonii* and is mainly confined to the outer fringes of saline flats. The two subspecies also grow together on the flats of Lake Goldsmith where, again, subsp. *adamsonii* appears to grow in the more saline areas. The only other site where the two subspecies have been found is at Corunnun, on the eastern shore of Lake Corangamite, but collected in different seasons, and not seen in sympatry (subsp. *adamsonii* on 25.i.2001, subsp. *limosa* on 17.xi.2012).

Lachnagrostis adamsonii subsp. *limosa* had been overlooked until the last decade because its long awns were considered diagnostic of *L. filiformis* (G.Forst.) Trin. (Common Blown-grass). However the non-geniculate awns of *L. adamsonii* subsp. *limosa* and its usually larger lemmas serve to separate it from *L. filiformis*.

Distribution: Scattered across the central region of the Volcanic Plain of western Victoria.

Habitat: Found growing on drying lake beds, depressions and on the outer flats of salt lakes, where soils are only slightly saline. Probably less tolerant of waterlogging than subspecies *adamsonii* and *ampla*.

Etymology: After the Latin for 'muddy': the same meaning for the Aboriginal word 'burrumbidj' from which Lake Burrumbeet derives its name.

Selected specimens examined: **VICTORIA.** 3 km SE of Weering on the Barpinba-Winchelsea Rd, 5.i.1996, *A.J. Brown 1153* (MEL), 4.ii.1997, *A.J. Brown 1314* (MEL) & 11.xii.2001, *A.J. Brown 1868* (MEL); Lake Goldsmith off Skipton Rd, 6.xii.1996, *A.J. Brown 1189, 1190* (MEL); Dashwood Station, Barunah, on the Mia Mia Ck, 19.xi.1997, *A.J. Brown 1360, 1361* (MEL) & 15.i.1998, *A.J. Brown 1490* (MEL); Lake Burrumbeet off Lake Burrumbeet Park, Cassidys Road, Burrumbeet, 6.xii.2007, *A.J. Brown 2150, 2153* (MEL); Lake Learmonth off Foreshore Rd, Learmonth, 6.xii.2007, *A.J. Brown 2157, 2158* (MEL); Lake Bookar, 29.xi.2008, *A.J. Brown 2450, 2451* (MEL); Foxhow, Lake Corangamite, 11.ii.2011, *A.J. Brown 2306* (MEL); Corunnun, Lake Corangamite, 17.xi.2012, *A.J. Brown 2596* (MEL).

Note

A few populations of *Lachnagrostis* have been collected from outside the normal range of *L. adamsonii* and have been informally regarded as *L.* aff. *adamsonii*, e.g. specimens with long (> 4.5 mm) but non-geniculate lemma awns from the Craigieburn grasslands (8.xii.1989, *D. Frood 036/89* (MEL); 1.i.1990, *D. Frood 001/90* (MEL); 5.ii.1990, *D. Frood 002/90* (MEL)); specimens with short (approx. 1.4 mm), non-geniculate lemma awns from the flats adjacent the Upper Yarra Reservoir (6.viii.2008, *A.M. Bennett s.n.* (MEL)). However, compared to *L. adamsonii*, these plants usually have flat leaves, 2–3.5 mm wide (rather than involute leaves, 0.5–2 mm wide in the unflattened state), usually higher spikelet to lemma length ratio (1.3–2.2 compared to 1.1–1.4) and smaller anthers (0.5 mm long or less compared to 0.5 mm long or more). In these features, these plants have greater affinity to *L. filiformis* than to *L. adamsonii*.

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A morphological search for *Lachnagrostis* among the South African *Agrostis* and *Polypogon* (Poaceae)

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Introduction

The grass subtribe Agrostidinae Fr. of tribe Poeae R.Br. contains 17 genera according to Soreng et al. (2007), of which *Lachnagrostis* Trin., *Agrostis* L. and *Polypogon* Desf. are three. Delimitation of these genera has often been problematic and no less so than in South Africa. Despite a number of recent studies, the phylogeny of the Poeae is still only partly resolved (Soreng et al. 2007; Quintanar et al. 2007; Schneider et al. 2009; Saarela et al. 2010). In addition, these phylogenies have not included adequate representation of the complete Agrostidinae. Until such work is undertaken, morphological assessments have a role to play in segregating species into circumscribed genera.

The genus *Lachnagrostis* includes 31 species endemic to Australia (Jacobs & Brown 2009) and New Zealand (Edgar & Connor 2000). Although first described by Trinius (1820), based on six Australasian taxa, *Lachnagrostis* has only been recognised in New Zealand and Australia in the last 40 years. Bentham (1878) in Australia and Cheeseman (1906) in New Zealand regarded currently recognised *Lachnagrostis* taxa as species of *Deyeuxia* P.Beauv. In New Zealand, Zotov (1965) recognised *Lachnagrostis* as distinct from *Deyeuxia* but only transferred some of the current taxa. It remained for Edgar (1995) to transfer the remainder, as well as to describe new species and subspecies for the New Zealand flora. In

Abstract

Three South African *Agrostis* L. taxa are transferred to *Lachnagrostis* Trin., as *L. eriantho* (Hack.) A.J.Br., *L. huttonioe* (Hack.) A.J.Br. and *L. polypogonoides* (Stapf) A.J.Br. on the basis of high palea to lemma length ratios and a lack of a trichodium net pattern on the lemma epidermis. However, the lemmas of *L. barbuligera* var. *borbuligera* and *A. barbuligero* var. *longipiloso* Gooss. & Papendorf have a trichodium net and do not belong in *Lachnagrostis*. Instead, they are morphologically similar to a group of montane tropical African *Agrostis*, which includes *A. kilimondscharico* Mez. and *A. monnii* (Hook.f.) Stapf. Previous transfers of *A. griquensis* Stapf and *A. viridis* Gouan to *Polypogon* are confirmed as appropriate, as they lack a trichodium net but, unlike *Agrostis* and *Lochnogrostis*, their spikelets disarticulate below the glumes.

Key words: taxonomy, Agrostidinae, lemma epidermis, trichodium net

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Australia, Mueller (1888) combined *Deyeuxio* and *Agrostis* under *Agrostis,* but Vickery (1940) recognised both genera, regarding current *Lachnogrostis* taxa as species of *Agrostis.* It was to be 60 years until *Lochnagrostis* was segregated from *Agrostis* by Jacobs (2001). Twenty years earlier, Rúgolo de Agrasar (1982) had ascribed the Australasian Common Blown-grass, naturalised in South America, to *L. filiformis* (G.Forst.) Trin. Rúgolo de Agrasar & Molina (2002) transferred the Ecuadorian endemic *A. sodiroono* Hack. to *L. sodiroono* (Hack.) Rúgolo & A.M.Molina, based on its similarities in gross morphological and lemma epidermis features to *L. filiformis.* They also made new combinations for the South African *A. barbuligera* Stapf, *A. lochnontho* Nees and *A. schlechteri* Rendle as *L. borbuligera* (Stapf) Rúgolo & A.M.Molina, *L. lachnontha* (Nees) Rúgolo & A.M.Molina and *L. schlechteri* (Rendle) Rúgolo & A.M.Molina, respectively, but without discussion of their morphological affinity to other *Lochnagrostis.* These new combinations do not appear to have been accepted in South Africa as yet (POSA 2009).

The genus *Agrostis* has 200+ species with representatives in Europe, Asia, North America, South America, Australasia and Africa. These grasses are largely confined to temperate regions and tropical mountains but some species do occur on subantarctic islands. Subdivision of this large and diverse genus has been attempted by a number of authors, as amply described by Björkman (1960). On the basis of a few distinct characters, other *Agrostis* taxa, apart from *Lachnogrostis,* have been segregated into small regional genera, e.g. *Podogrostis* (Griseb.) Scribn. & Merr. (1910) in the Americas, *Neoschischkinia* Tzvelev (1968) in southern Europe and North Africa, *Keniochloo* Melderis (1956) in East Africa and *Zingero* P.A.Smirn. (1946) for the monotypic *Z. biebersteiniana* (Claus) P.A.Smirn. of the Caucasus Mountains. However, diffuse morphological character boundaries and/or intergeneric hybridisation between members of the subtribe Agrostidinae (e.g. *Colomogrostis* Adans. and *Deyeuxia* Clarion ex P.Beauv., *Calomagrostis* and *Ammophila* Host, *Agrostis* and *Polypogon* Desf.) have been the source of uncertainty in the placement of some taxa.

The genus *Polypogon* has approximately 20 species, with the majority being endemic to Mediterranean Europe and south-west Asia and a few species native to the Americas, Africa and Australia., The southern European *Polypogon monspeliensis* Desf. has become a weedy introduction throughout the world. Aside from some confusion surrounding the nomenclature of *Agrostis* × *Polypogon* hybrids, the taxonomic treatment of *Polypogon* taxa outside Eurasia has been problematic. In Africa, some species have been historically placed in *Agrostis,* a number of South American taxa have been transferred from *Polypogon* to *Choetotropis* Kunth on the basis of intermediate character states between typical *Agrostis* and *Polypogon* (Björkman 1960) and the generic placement of the Australian species, *P. tenellus* R.Br. has been questioned (Weiller et al. 2009).

Stapf (1900) recognised eight *Agrostis* and two *Polypogon* species for South Africa: the native *A. borbuligera* Stapf, *A. bergiona* Trin., *A. griquensis* Stapf, *A. lochnantho* Nees, *A. natalensis* Stapf, *A. polypogonoides* Stapf, *A. schlechteri* Rendle (in the addendum) and *P. tenuis* Brogn, and the exotic *A. verticillota* Vill. and *P. monspeliensis* (Table 1). Soon after, Hackel (1904) described *A. eriontha* Hack. from the Transvaal and Stapf (1908) described *A. suovis* Stapf from Natal. Bews (1918) listed the same *Agrostis* and *Polypogon* species Stapf (1900) had accepted and only added *A. suavis.* Wood (1908) had earlier reported that Dr. Stapf considered *A. suavis* to be closely related to *A. eriantho,* differing only in its divaricate, effuse panicle compared to the narrow contracted panicle of the latter. If accepted as the same taxon, the name *A. eriontha,* as the earlier name, should have priority.

Goossens and Papendorf (1945) listed ten *Agrostis* species for South Africa, with the inclusion of *A. huttoniae* (Hack.) C.E.Hubb. ex Gooss. & Papendorf. The name *A. semiverticillata* (Forssk.) C.Chr. replaced *A. verticillata* Vill. and the name *A. eriantha* Hack. replaced *A. suavis* Stapf. They also described three new varieties: *A. borbuligera* var. *longipiloso* Gooss. & Papendorf, *A. eriontho* var. *planifolia* Gooss. & Papendorf and *A. lachnontha* var. *globro* Gooss. & Papendorf.

Goossens and Papendorf (1945) separated *A. huttoniae* from *A. lochnantho* on the basis that the former had a long, hairy callus and a distinct rachilla extension. Launert (1971) considered *A. huttoniae* to be synonymous with *A. lochnantho* and although Ross (1972) added *A. huttonioe* to the *Floro of Notal,* he was concerned that it lacked satisfactory characters to differentiate it from *A. lochnontho.*

Table 1. *Agrostis* and *Polypogon* taxa in South African treatments (accepted taxon names in bold)

Stapf (1900)	Goossens & Papendorf (1945)[1]	Gibbs Russell et al. (1990)
P. adscensionis Trin. (syn. *P. tenuis* Brongn.)		
A. aristulifera Rendle (syn. *A. bergiana* Trin.)		
A. alba var. *schimperiana* Engl. (syn. *A. verticillata* Vill.)		
	A. albimontana Mez (syn. *A. bergiana* Trin.)	
		***A. avenacea** J.F.Gmel.
A. barbuligera Stapf	**A. barbuligera** Stapf	**A. barbuligera** Stapf
	A. barbuligera var. *longipilosa* Gooss. & Papendorf	**A. borbuligera** var. *longipilosa* Gooss. & Papendorf
A. bergiana Trin.	**A. bergiana** Trin.	**A. bergiana** Trin.
A. bergiona var. *loeviscula* Stapf	**A. bergiana** var. *laeviscula* Stapf (syn. *A. bergiana* Trin.)	**A. bergiana** var. *laeviscula Stapf*
	A. bergiana var. *mutica* Hack. (syn. *A. bergiana* Trin.)	
A. capensis Steud. (syn. *A. bergiana* Trin.)		
	A. continuata Stapf [unable to verify diff. to *A. natalensis*]	**A. continuata** Stapf
A. dregeana Steud. (syn. *A. lachnontho* Nees)		
A. ecklonis Trin. (syn. *A. bergiana* Trin.)		
	A. eriantha Hack.	**A. eriontha** Hack.
	A. eriantha var. *planifolia* Gooss. & Papendorf	**A. eriantha** var. *planifolia* Gooss. & Papendorf
		***A. gigantea** Roth
	A. huttoniae (Hack.) C.E.Hubb. ex Gooss. & Papendorf	**A. huttoniae** (Hack.) C.E.Hubb. ex Gooss. & Papendorf (syn. *A. lachnantha* Nees)
A. griquensis Stapf	**A. griquensis** Stapf	*P. griquensis* (Stapf) Gibbs Russell & Fish
A. gymnostyla Steud. (syn. *Cinna mexicana Beauv.*)		
A. lachnantha Nees	**A. lachnantha** Nees	**A. lachnantha** Nees
	A. lachnantha var. *glabro* Gooss. & Papendorf	*A. lachnantha* var. *glabra* Gooss. & Papendorf (syn. *A. lachnantha* Nees)
		P. minutiflorus Pilg. (syn. *P. griquensis* (Stapf) Gibbs Russell & Fish)
***P. monspeliensis** Desf.		***P. monspeliensis** Desf.
P. monspeliensis var. *capensis* Steud. (syn. *P. monspeliensis* Desf.)		
		***A. montevidensis** Spreng. ex Nees
A. natalensis Stapf	**A. notalensis** Stapf	*A. natalensis* Stapf (syn. *A. continuata* Stapf)
A. neesii Trin. (syn. *A. lachnantha* Nees)		
A. panicea (L.) Aiton (syn. *P. monspeliensis* Desf.)		
	A. papposa Mez (syn. *A. huttoniae* (Hack.) C.E.Hubb. ex Gooss. & Papendorf)	
	A. phalaroides Hack. (syn. *A. natalensis* Stapf)	
A. polypogonoides Stapf	**A. polypogonoides** Stapf	**A. polypogonoides** Stapf
P. polysetus Steud. (syn. *P. monspeliensis* Desf.)		
A. schlechteri Rendle	**A. schlechteri** Rendle	**A. schlechteri** Rendle
	***A. semiverticillata** (Forssk.) C.Chr.	***A. semiverticillata** (Forssk.) C.Chr. (syn. *P. viridis* (Gouan.) Breistr.)
		***P. semiverticillatus** (Forssk.) Hyl. (syn. *P. viridis* (Gouan.) Breistr.)
A. stolonifera Thunb. (syn. *A. bergiana* Trin.)		
P. strictus Nees (syn. *P. tenuis* Brongn.)		*P. strictus* Nees
	A. suavis Stapf (syn. *A. eriantha* Hack.)	
P. tenuis Brongn.		

Table 1 cont. *Agrostis* and *Polypogon* taxa in South African treatments (accepted taxon names in bold)

Stapf (1900)	Goossens & Papendorf (1945)[1]	Gibbs Russell et al. (1990)
	A. subulifolia Stapf (syn. *A. bergiana* Trin.)	*A. subulifalia* Stapf
***A. verticillata* Vill.**	***A. verticillata* Vill. (syn. *A. semiverticillata* (Forssk.) C.Chr.)**	
A. vestita Hochst. ex A. Rich. (syn. *A. lachnantha* Nees)		
		***P. viridis* (Gouan.) Breistr.**

* exotic taxon

1 deals only with Agrostis taxa

Ross (1972) included *A. subulifolia* Stapf and *A. bergiana* var. *laeviscula* Stapf to the plants of Natal, as did Gibbs Russell et al. (1990) to the grasses of southern Africa (Table 1), despite Goossens and Papendorf (1945) having previously considered *A. subulifolia* to be synonymous with *A. bergiana* Trin. and not recognising any varieties of *A. bergiana* (Table 1).

Gibbs Russell et al. (1990) added the Australasian *A. avenacea* J.F.Gmel. (syn. *Lachnagrostis filiformis* (G.Forst.) Trin.), the European and temperate Asian *A. gigantea* Roth. and the South American *A. montevidensis* Spreng. ex Nees. to the list of southern African *Agrostis* and recognised *A. continuata* Stapf for South Africa, treating *A. natalensis* in synonymy. They transferred *A. griquensis* Stapf to *Polypogon* as *P. griquensis* (Stapf) Gibbs Russ. & Fish (not validly so until Fish (2006)) and treated *A. semiverticillata* (Forssk.) C.Chr. as *Polypogon viridis* (Gouan.) Breistr. (Table 1). Gibbs Russell et al. (1990) also listed *P. strictus* Nees but not *P. tenuis*. Although Stapf (1900) treated *P. tenuis* from Ascension Island (mid South Atlantic Ocean) in synonymy with *P. strictus*, as has Clayton et al. (2002 onwards) (*P. tenuis* having priority as the earlier name), Goldblatt and Manning (2000) and Raimondo et al. (2009) did not do so.

To add to the transfers from *Agrostis* to *Polypogon*, Clayton et al. (2006 onwards) invalidly treat *A. polypogonoides* Stapf as *P. polypogonoides* (Stapf) Forsan: their attribution of the 'author' Forsan being in error – this merely meaning 'perhaps' in Latin.

As part of a wider study of *Lachnagrostis* by Brown (2013), the opportunity to examine herbarium specimens of South African collections raised the possibility that taxa accepted in that country as *Agrostis* or *Polypogon* may better conform to Australasian concepts of *Lachnagrostis*. This paper examines the morphological evidence for the generic placement of all the native and introduced South African *Agrostis* and *Polypogon* into *Lachnagrostis*, *Agrostis* or *Polypogon*.

Materials and methods

Morphological characters that are considered critical in establishing generic concepts of *Agrostis*, *Lachnagrostis* and *Polypogon* were compiled from the literature for South African and Australasian taxa (Table 2). The values of these characters were derived from the original descriptions of the taxa, unless such were not provided, wherein they were supplemented from later descriptions. Additional descriptions of Eurasian and North American taxa were also consulted to provide a wider context for these genera. Owing to the varied treatment of *Agrostis* and *Polypogon* in Central and South America (e.g. sometimes as *Bromidium* Nees & Meyen and *Chaetotropis*, respectively), these taxa were mostly excluded from consideration in the current study. Likewise, in order to simplify the study, attention is not given to East, Central or West African *Agrostis* and *Polypogon*, although it is recognised that an Africa-wide study of these taxa would be beneficial in due course.

Forty-nine herbarium specimens of South African *Agrostis*, *Polypogon* and *Lachnagrostis* taxa housed at MEL and on loan from PRE (Appendix 1) were examined, compared to the taxon character values of Table 2, and any departures noted. Ten herbarium specimens of New Zealand endemic *Lachnagrostis* (Appendix 1) were used to further assess the range of palea to lemma length ratio in this group.

Scanning Electron Microscope (SEM) images of the lemma epidermis from the largely unpublished work of the late Surrey Jacobs (1946–2009), formerly of the National Herbarium of New South Wales (NSW) were

examined and compared for a range of South African and Australasian *Agrostis* and *Lachnagrostis* collections at NSW. The SEM images were obtained during 1985–1986 in accordance with Jacobs (2001). A few SEM images of additional taxa were more recently made at The University of Melbourne.

Comparisons between genera for the selected characters were made to assess which were most consistent in segregating taxa. New combinations were made in *Lachnagrostis* where character states suggested taxa were better placed.

Results

A number of spikelet morphological features have been, or are currently, used to segregate taxa into

Table 2. Key morphological features (derived from a range of type descriptions, floras and online databases) of native and introduced South African *Agrostis*, *Lachnagrostis* and *Polypogon* taxa compared to a selection of Australasian taxa

Taxon[1]	Panicle form	Spikelet disarticulation[2]	Awned glumes	Glume surface[3]	Rachilla extension	Lemma length (mm)	Lemma hairiness	Palea to lemma length ratio[4]	Lemma awn length (mm)	Lemma awn attachment[5]	Anther length (mm)
South Africa											
A. oristulifera[6]	contracted	above	no	smooth	absent	1.5	glabrous	0.75, 0.90[7]	0–1.0	> 90	?
A. bergiono	open	above	no	smooth	absent	1.5–2.5	glabrous	0.80	0–2.0	50	1.0
A. continuota[8]	contracted	above	no	scabl	present	2.1	sparse	0.33–0.50	4.2	< 25[9]	1.6
A. eriontho	contr-open	above	no	smooth	absent	3.0–3.5	covered	0.90	4.0	40–50[9]	2.0
A. huttonioe[10]	contracted	above	no	smooth	present	2.5	glabrous	0.95	0–0.5	> 66	1.0
A. notolensis	contracted	above	no	scabl	absent	2.1	glabrous	0.25–0.33	2.1	< 10[9]	1.0
A. polypogonoides	contracted	above	yes	scabl	absent	2.1	moderate	0.90	3.0	50	1.5
A. suovis[11]	open	above	no	smooth	present	3.5	covered	0.90	5.0–6.0	40–50[9]	?
A. subulifolio[12]	open	above	no	smooth	absent	1.7–2.7	glabrous	0.66	0–1.5	33	1.5
**A. gigonteo*	open	above	no	smooth	absent	1.5–2.0	glabrous	0.50–0.65	rarely present		1.0–1.5
**A. montevidensis*	open	above	no	smooth	absent	1.5–2.0	glabrous	0.08	2.0–2.5	66–75	0.8
L. borbuligero	open	above	no	smooth	present	2.7–5.0	moderate	0.75	3.0–6.0	10	2.6
L. lochnontho	contracted	above	no	smooth	absent	1.5–2.0	covered	0.80–0.95	0–0.5	90	0.5–0.8
L. schlechteri	open	above	no	smooth	present	2.0–2.5	moderate	0.66–0.90	4.0	50	1.9
P. griquensis[13]	contracted	below	yes	scabl	absent	1.0	glabrous	0.66–0.75	0.4–0.5	> 90	0.3
P. strictus	spiciform	below	yes	scabrous	absent	1.5	glabrous	1.00	5.0–10.0	> 90	0.3–0.7
**P. monspeliensis*	spiciform	below	yes	scabrous	absent	0.9–1.5	glabrous	0.90	0–2.0	> 95	0.4–0.7
**P. viridis*[13]	contracted	below	no	scabrous	absent	0.9–1.0	glabrous	1.00	absent		0.4–0.5
Australasia											
A. oustroliensis[14]	open	above	no	smooth	absent	1.7–2.0	glabrous	0	rarely present		0.2–0.5
A. dyeri[15]	open	above	no	smooth	absent	2.3–3.3	glabrous	0.07	rarely present		0.6–1.2
A. imbecillo[15]	contracted	above	no	smooth	absent	1.5–1.9	glabrous	0.06–0.10	absent		0.6–1.0
A. muelleriono[14,15]	contracted	above	no	smooth	absent	1.3–2.0	glabrous	0.17	rarely present		0.5–0.8
A. muscoso[15]	contracted	above	no	smooth	absent	1.2–1.4	glabrous	0.16–0.30	absent		0.4–0.6
A. pollescens[15]	open	above	no	smooth	absent	1.2–1.8	glabrous	0.30–0.33	absent		0.4–0.7
A. porvifloro[14]	open	above	no	smooth	absent	1.5–2.0	glabrous	0–0.13	absent		0.3–0.5
A. petriei[15]	open	above	no	smooth	absent	2.0–2.6	glabrous	0.08	2.0–3.0	50	1.3–1.8
A. propinquo[14]	open	above	no	smooth	absent	1.3–2.0	glabrous	0–0.08	absent		< 0.5
A. subuloto[15]	contracted	above	no	cilio-scabr	absent	1.3–1.6	glabrous	0.25	rarely present		0.5–0.7
A. venusto[14]	open	above	no	smooth	absent	1.5–2.3	glabrous	0–0.08	2.2–5.0	10–50	0.2–0.6

Table 2 cont. Key morphological features (derived from a range of type descriptions, floras and online databases) of native and introduced South African *Agrostis*, *Lachnagrostis* and *Polypogon* taxa compared to a selection of Australasian taxa

Taxon[1]	Panicle form	Spikelet disarticulation[2]	Awned glumes	Glume surface[3]	Rachilla extension	Lemma length (mm)	Lemma hairiness	Palea to lemma length ratio[4]	Lemma awn length (mm)	Lemma awn attachment[5]	Anther length (mm)
L. adamsonii[14]	open	above	no	smooth	present	2.0–2.5	glabr–slight	0.90	1.5–3.5	66–90	0.4–0.7
L. aemula[14]	open	above	no	smooth	present	1.8–3.0	covered	0.90	5.0–10.0	25–60	0.6–1.2
L. billardierei[14,15]	open	above	no	smooth	present	2.5–4.5	glabrous	0.80	5.0–9.0	30–45	0.5–1.0
L. deflexa[14]	open	above	yes	fine scabl	present	2.2–2.7	glabr–slight	0.70–0.90	4.5–6.5	45–65	0.5–0.7
L. filiformis[14,15]	open	above	no	smooth	present	1.5–3.5	mod–sparse	0.80	3.5–5.5	45–55	0.2–0.5
L. limitanea[14]	open	above	no	micro scabl	present	1.0–2.0	glabrous	0.90–0.95	absent		0.6
L. littoralis[15]	open	above	no	smooth	present	1.8–2.5	moderate	0.95	3.0–6.0	50	0.4–0.7
L. leptostachys[15]	open	above	no	spars scabl	present	2.5–3.0	moderate	0.50–0.66	4.0–6.0	50–66	0.8–1.2
L. lyallii[15]	open	above	no	smooth	variable	2.0–2.5	covered	0.50–0.95	2.0–6.0	50	0.6–1.2
L. meionectes[14]	open	above	no	smooth	present	2.0–2.5	covered	0.90	2.0–4.0	70–80	1.0
L. morrisii[14]	open	above	no	smooth	present	1.7–2.6	glabrous	0.80–0.95	0.2–1.5	95	0.4–0.6
L. pilosa[15]	open	above	no	smooth	present	2.0–2.8	covered	0.50–0.60	4.5–8.5	50	0.6–1.2
L. rudis[14]	open	above	no	scabl	present	1.1–2.2	glabr–slight	0.95	0–1.4	70–95	0.5–0.7
L. striata[15]	contracted	above	no	smooth	present	1.2–2.0	covered	0.66–0.95	0.2–2.0	66	0.2–0.5
P. tenellus[15]	contracted	below	yes	scabl–cilio	absent	2.0–2.5	glabrous	0.50	13.5–19.0	50	0.3–0.4[16]

* naturalised introduction;
1 character information for type subspecies or variety only;
2 disarticulation point refers to above or below the glumes;
3 excluding the usually scabrous keel; assumed smooth if not described; scabl = scaberulous, scabr = scabrous, spars = sparsely, cilio = ciliate
4 a palea to lemma length ratio of 0.90 is used where the original description of palea is 'subequal' or 'a little shorter than lemma'
5 % lemma length from base
6 considered by Björkman (1960) to be a separate though closely related species to *A. bergiana*
7 values derived from the descriptions of Rendle (1899) and Björkman (1960) respectively
8 considered by most authors to be synonymous with *A. natalensis*
9 awn attachment is described as 'supra basin' (above base) for *A. continuata*, as 'recta supra basin' (just above the base) for *A. natalensis* and as 'v. infra medium' or 'paulo infra medium' (a little below the middle) for *A. eriantha* and *A. suavis* and is here assumed to be in the lower quarter, lower tenth and 40–50% of the lemma, respectively
10 considered by most authors to be synonymous with *L. lachnantha*
11 considered by some authors to be synonymous with *A. eriantha*
12 considered by some authors to be synonymous with *A. bergiana*
13 considered here to be *Polypogon* as for Gibbs Russell et al. (1990)
14 Australian taxa
15 New Zealand taxa
16 current measurement (Darkin Swamp, 20.x.2011, *A.J. Brown 2553* (MEL)), taxon with one anther only

Agrostis, *Polypogon* and *Lachnagrostis*. These include the disarticulation point of the spikelet, the shape, surface and awned state of the glumes, the presence of a rachilla extension, the surface of the lemma and the length of the palea in relation to the lemma.

Glume shape and awns

Differentiation of *Polypogon* from *Agrostis* has been historically based on the presence of awns on the glumes. When Desfontaines (1798) originally described *Polypogon*, based on *P. monspeliensis*, he noted 'Calyx exterior biglumis, uniflorus; glumis aristatis' (i.e. outer glumes two with a single floret; glumes awned) and 'Calyx interior brevior, biglumis; glumâ alterâ aristatâ; aristâ terminali' (i.e. the floret shorter than the outer glumes, with two glumes [lemma and palea]; alternate glume [lemma] with a terminal awn). Palisot de Beauvois (1812) described *Polypogon* as having glumes with a long awn ('longè setagera') arising just below emarginate, obtuse apices.

For South Africa, Stapf (1900) described the glumes of *P. monspeliensis* as 'shortly 2-lobed or emarginate ...

awn 2–3 lin. [4.2–6.4 mm] long' and those of *P. tenuis* as 'minutely or obscurely 2-lobed ... awn finely capillary, up to 1 lin. [2.1 mm] long'. Stapf (1897, 1900) noted an affinity of *A. griquensis* with *A. verticillata* ('sed gracilior' – but more slender), on the basis of their erect, narrow, sometimes interrupted 'spike-like, dense' panicles, which set them apart from the 'very lax, effuse or contracted' panicles of *Agrostis*. However, their lack of glume awns were the key criterion for Stapf (1900) to not transfer these taxa to *Polypogon*, even though he recognised that they also shared 'obtuse, mucronulate or emarginate' glumes, as opposed to the 'acute' glumes of the rest of the *Agrostis* in his key.

Awned glumes are seemingly not confined to *Polypogon*. Beetle (1945) described a number of North American *Agrostis* taxa (*A. ampla* Hitchc., *A. microphylla* Steud., *A. inflata* Beal and *A. kennedyana* Beetle) as having awned glumes. Likewise, in Australia, Vickery (1941) noted for *Deyeuxia forsteri* var. *aristata* Benth. (syn. *A. avenacea* J.F.Gmel., *L. filiformis* (G.Forst.) Trin.) that 'outer glumes produced into a long point' and Brown (2008) described *L. deflexa* A.J.Br. and *L.* x*contracta* A.J.Br. as having 'each glume extended into a fine seta' (1.0–1.7 mm and 0.6–1.6 mm long, respectively). However, there is a distinct difference between the 'awn' of these taxa which are extensions of the keel from the acuminate point of the glume, and those of *Polypogon*, which arise from a terminal notch or just below the obtuse glume apex and usually appear to be a separate structure from the keel. Stapf (1900) noted that *A. polypogonoides* was the only South African *Agrostis* species recognised as having awned glumes: 'glumes subequal, lanceolate, acute, produced into fine fragile scabrid bristles (up to 1½ lin. (i.e. 3.2 mm) long)'. He stated that this taxon 'comes very near to *Polypogon*, the only difference being in the habit, and the absence of a terminal notch in the persistent glumes'.

Spikelet disarticulation

Bentham (1887) appears to be the first author to unequivocally use the character of disarticulation of the spikelet below the glumes, so that part of the pedicel (or stipe) falls with it, as a diagnostic character for *Polypogon*. However, a much earlier reference by Ruchinger (1818) stating 'Cal. [calyx] di due valve, restato, con un solo fiore' (i.e. of two glumes, retained with a single flower) may relate to the same feature and suggests that this trait had been observed by others. This disarticulation character was so unusual to Bentham (1887) that he erroneously placed *Polypogon* in Tribe Andropogoneae Dumort., with which only members of Tribe Paniceae R.Br. shared the feature in common. In recent grass treatments, the spikelet disarticulation point has become the major diagnostic feature that distinguishes *Polypogon* from *Agrostis* (Clayton & Renvoize 1986; Sell & Murrell 1996; Barkworth 2007).

For South Africa, Stapf (1900) described *Polypogon* spikelets as 'disarticulating from the pedicels' but was obviously unware that both *A. griquensis* and *A. verticillata* possess this character (Table 1). Gibbs Russell et al. (1990) placed both taxa into *Polypogon*, stating that their transfer of *A. griquensis* to *P. griquensis* was on the basis that 'the entire floret plus a short stipe together form the disseminule'. Fish (2006) formally, though belatedly, transferred *A. griquensis* to *P. griquensis*. In Clayton et al. (2006 onwards)'s treatment of *A. polypogonoides* as *P. polypogonoides* (Stapf) Forsan they describe it as having spikelets 'falling entire: deciduous with the pedicel' but as noted above, Stapf (1900) stated that *A. polypogonoides* has 'persistent glumes'.

Glume surface

The surface of the glumes of *Polypogon* have been variously described (sometimes depending on the species) as minutely pilose (Trinius 1841), scaberulous (Stapf 1900), rough (Tutin 1962), rough with minute points (Hubbard 1968), scabrid (Tutin 1980), hairless but hispid or hairy and usually scabrous (Watson & Dallwitz 1992 onwards), scabrous, ciliolate or with inflated bristles (Walsh & Entwisle 1994), asperulous (Clayton et al. 2006 onwards), echinate, scabridulous or hispidulous (Barkworth 2007) and hispid or puberulous (Keshavarzi et al. 2007), and often with ciliate margins. Although descriptions vary between species and sometimes within the same species, these observations reflect a general roughness or coarse hairiness to the glume surfaces.

The glumes of the majority of *Agrostis* are described as smooth or shiny and glabrous (Edgar & Forde 1991; Harvey 2007; Watson & Dallwitz 1992 onwards; Clayton et al. 2006 onwards), but this difference in character does not appear to have ever been used to differentiate

between the two genera. This is likely due to the occasional scaberulous glume surfaces in *Agrostis*. For instance, according to Barkworth et al. (2007), the glumes of a few North American *Agrostis* are scabrous, though only towards the apices (e.g. *A. hyemolis* (Walter) Britton, Sterns & Poggenb., *A. exarato* Trin.) or are scabridulous across the body (e.g. *A. hendersonii* Hitchc., *A. microphyllo* Steud.) or are very occasionally densely scabrous (e.g. *A. densifloro* Vasey).

The Australasian taxa of *Agrostis* and *Lachnagrostis* are likewise variable. Again, while most species have smooth glumes (except for the keels), a number are scabrous to some degree and many are occasionally sparsely scaberulous. Edgar and Forde (1991) describe the glumes of the subantarctic *A. magellenica* Lam. (syn. *P. mogellonicus* (Lam.) Finot) as finely scabrous and those of the New Zealand endemic, *A. subuloto* Hook.f. as ciliate-scabrous. In Australia, Vickery (1941) described the lateral faces of the glumes of *A. limitonea* J.M.Black (syn. *L. limitaneo* (J.M.Black) S.W.L.Jacobs) as microscaberulous, *A. rudis* Roem. & Schult. (syn. *L. rudis* (Roem. & Schult.) Trin.) as scabrous and *A. plebeia* R.Br. (syn. *L. plebeia* (R.Br.) Trin.) as slightly scaberulous. Brown and Walsh (2000) described *A. collicola* D.I.Morris (syn. *L. collicola* (D.I.Morris) S.W.L.Jacobs) as having densely and finely scaberulous glumes and Brown (2008) described *L. deflexo* and *L. xcontracto* as having glumes with finely scaberulous lateral surfaces and marginal cilia. Although, the glume surfaces of these Australian taxa may approach the hispid and ciliate glumes of *Polypogon*, most other features of the spikelet, including glume shape are clearly not *Polypogon*-like. By contrast, the Australian *P. tenellus* R.Br. has both the glume characters of *Polypogon* (i.e. awned, scaberulous to ciliate glumes) and disarticulation of the spikelet below the glumes.

For South African taxa, Stapf (1900) included *A. notolensis and A. polypogonoides* in his descriptions of scaberulous glumes as he did for *P. monspeliensis, P. tenuis, A. griquensis* (syn. *P. griquensis*) and *A. verticillata* (syn. *P. viridis*). Current cursory examination of specimens of these species (Appendix 1) and other *Agrostis*/*Lachnagrostis* taxa shows a wide range in surface covering but suggests that utilisation of a uniform and detailed set of criteria and descriptions across replicated taxon examples may reveal some generic diagnostics. For example, the densely ciliate margins of many *Polypogon* species are rarely, if ever, observed in *Agrostis* or *Lochnagrostis*.

Palea to lemma length ratio and rachilla extension

Jacobs (2001) characterised *Lachnagrostis* as differentiated from *Agrostis* by 'i) a palea almost as long as the lemma (always > 50%); ii) an obvious and well-developed hairy rachilla extension that, with the apical hairs, may be almost as long as the lemma; and iii) a tendency for the whole inflorescence to become detached and act as the diaspore, though this character is not always obvious and appears to be suppressed in some species'. As the latter feature is not readily determined from herbarium specimens and none of the descriptions of South African taxa mention such, it cannot be used to discriminate between genera in the current analysis.

Comparison of Australasian *Agrostis* and *Lachnagrostis* taxa (Table 2) show clear differences between genera in palea to lemma length ratio and rachilla extension production (except sometimes in *L. lyallii* (Hook.f.) Zotov) (i.e. small paleas and no rachilla extension in *Agrostis* and long paleas and a rachilla extension in *Lochnogrostis*). Such is not the case for the South African taxa (native and exotic). Among *Agrostis*, only *A. natolensis* and *A. montevidensis* conform to the normal character states. Although lacking a rachilla extension, *A. bergiana* (including *A. aristulifera*), *A. eriontho* and *A. polypogonoides* have long paleas and *A. subulifolio* and *A. gigantea* have moderately long paleas. In this respect they have similar characters to *Polypogon* (Table 2). On the other hand, *A. continuota* has the small paleas of *Agrostis* but does produce a rachilla extension. The two taxa, *A. huttonioe* and *A. suovis*, generally regarded as synonymous with *L. lochnantha* and *A. eriantha* respectively, have the two character states of *Lachnagrostis*. However, among the three South African *Lachnagrostis* taxa, only *L. barbuligera* and *L. schlechteri* conform to normal character states, for even though *A. lachnantha* was transferred to *Lochnogrostis* by Rúgolo de Agrasar and Molina (2002), it usually does not have a rachilla extension. Of ten *L. lachnontha* specimens examined in the current study (Appendix 1), only one showed any rachilla extension and even this observation was inconsistent among spikelets.

Table 3. Details of samples and their Scanning Electron Microscope images (Figs. 1, 2 and 3) for a selection of native and introduced South and East African and native Australasian *Agrostis*, *Polypogon* and *Lachnagrostis* taxa and the lemma epidermis pattern present (using the classification of Jacobs 2001)

Former taxon name[1]	Updated taxon name[2]	Lemma base image[9]	Lemma epidermis pattern	Location	Collector	Collection date	Herb. no.[10]
A. bergiono var. *mutica*[4]	*A. bergiono*	Fig. 1a	trichodium net	Capcolonie, S. Afr.	R. Schlechter 2344	15.iii.1893	NSW852639
A. neesii (*L. lochnontho*)[5]	*A. bergiono*	not shown	trichodium net	Austro-Africanae	R. Schlechter 10081	22.i.1897	NSW883631
A. notolensis	*A. continuoto*[6]	Fig. 1b	trichodium net	Olifant River, S. Afr.	R. Schlechter 4042	23.xii.1893	NSW852648
A. montevidensis	–	Fig. 1c	trichodium net	Punta Gorda, Uruguay	C. Osten 5310	20.ii.1910	NSW852646
A. gigonteo	–	Fig. 1d	raised margins	Yarnton, UK	C.E. Hubbard 10671	20.vii.1941	NSW883624
A. venusto	–	Fig. 1e	trichodium net	Hedley Tarn, NSW	J. Thompson 2859	6.ii.1978	NSWS48381
A. porvifloro	–	Fig. 1f	trichodium net	Queenstown – Strahan, Tas.	J. Vickery s.n.	20.i.1949	NSW7495
A. oustroliensis	–	Fig. 1g	trichodium net	Mt Wellington, Tas.	L. Rodway s.n.	i.1893	NSWS48376
A. propinquo	–	Fig. 1h	trichodium net	One Tree Hill, Vic.	J. Vickery s.n.	22.i.1935	NSWS46266
A. muelleriono	–	SJ Fig.1a	trichodium net	Mt Somers, NZ	V.D. Zotov s.n.	3.iii.1938	NSWS48447
A. lochnontho	*L. lochnontho*	Fig. 2a	raised margins	Witzieshoek, S. Afr.	P.C.V. du Toit s.n.	21.iii.1975	NSW852644
A. schlechteri[4]	*L. schlechteri*	Fig. 2b	smooth	Villiersdorf, S. Afr.	R. Schlechter 9909	8.i.1896	NSW852652
A. suovis[4] [isotype]	*L. eriontho*[3]	Fig. 2c	raised margins	Van Reenen, S. Afr.	J. Medley Wood 8913	29.i.1903	NSW852653
A. eriontho	*L. eriontho*[3]	not shown	raised margins	Tafelkop, S. Afr.	N.J. Devenish 3843	1982	PRE664945
A. polypogonoides[4]	*L. polypogonoides*[3]	Fig. 2d	smooth	Villiersdorf, S. Afr.	R. Schlechter 9915	8.i.1896	NSW852650
A. odomsonii	*L. odomsonii*	Fig. 2e	smooth	Melbourne, Vic.	Adamson 226	12xi.1853	NSWS46289
A. ovenoceo	*L. filifomis*	Fig. 2f	smooth	Grafton, NSW	M.J.E. Squire s.n.	1.xi.1932	NSW134519
A. meionectes	*L. meionectes*	Fig. 2g	raised margins	Upper Betts Ck, NSW	J. Thompson 2822	5.ii.1978	NSWS48653
A. oemulo	*L. oemulo*	Fig. 2h	smooth	Llanthgothlin, NSW	E.N. McKie 2510	7.i.1948	NSW13387
A. billordierei	*L. billordierei*[7]	SJ Fig.1c	smooth	Dolphin Sands, Tas.	A.M. Buchanan 4763	10.xii.1984	NSW532486
A. borbuligero	*L. borbuligero*[8]	Fig. 3a	trichodium net	Bethlehem, S. Afr.	Ellis 2404	21.iii.1975	NSW852637
A. borbuligero	*L. borbuligero*[8]	not shown	trichodium net	Tschlangana Valley, S. Afr.	Jacot-Guillamod 3737	8.i.1960	PRE40497
A. b. var. *longipiloso*	–	Fig. 3b	trichodium net	Bethlehem, S. Afr.	Roberts 3280	24.i.1965	PRE38919
A. burttii	*A. kilimondschorico*	Fig. 3c	trichodium net	Belgian Congo	J. Louis 5399	20.viii.1937	NSW883629
A. trochyphyllo	–	Fig. 3d	trichodium net	Mt Kenya, Kenya	Schelpe 2879	29.viii.1949	NSW883632
A. mildbreodii	*A. quinqueseto*	not shown	trichodium net	Congo Belgica	J. Louis 5371	viii.1937	NSW883628
P. monspeliensis	–	Fig. 3e	smooth	Fish Creek, Vic.	A. Paget 1148	5.xii.1994	MEL2026751
A. schimperono	*P. schimperiono*	Fig. 3f	raised margins	Lushoto District, Tanzania	H. Faulkner 4475	19.xi.1970	NSW883630
A. griquensis[4]	*P. griquensis*	Fig. 3g	smooth	Bloemfontein, S. Afr.	G. Potts 2467	6.x.1917	NSW852640
A. semiverticilloto	*P. viridis*	Fig. 3h	raised margins	Tarrabandra, NSW	E. McBarron 5278	8.xi.1950	NSW13651

1 name under which SEM imaged
2 current name
3 comb. nov. made in this paper
4 name provided by Goossens and Papendorf (1945) for duplicates of these collections
5 a specimen sheet identified as *Agrostis neesii* (*A. lochnontho*) at the Zürich Herbaria bears similar details to this sample and is probably a duplicate (Western Cape Province, Konde 8okkevelt in monte Tafelberg, 5000 ft., 22.i.1897, R. Schlecter 10081, Z-000073075)
6 name given in synonymy but some character distinctions may warrant review of this taxon
7 subsp. *tenuiseta*
8 synonmous name but taxon rejected in this paper as a species of *Lochnagrostis*
9 lemma base images relate to those in the current paper except for SJ = Jacobs (2001)
10 NSW specimens imaged by S.W.L. Jacobs; PRE and MEL specimens imaged by T. Schuster and H. Merrylees

The palea to lemma length ratio for Australasian *Agrostis* range from 0–0.33 (Table 2). According to the measurements of Björkman (1960), palea to lemma length ratio among Eurasian *Agrostis* (after discarding taxa transferred to *Neoschischkinia*) varied from 0–0.70. Among taxa with the highest values were *A. stolonifera* L. and *A. gigonteo*. Reported values by Jacobs and Brown (2009) of all the Australian *Lachnogrostis* show palea to lemma length ratio of at least 0.75, except for the rare and possibly extinct *L. drummondiona* (Steud.) S.W.L.Jacobs, at 0.65. However, the descriptions of New Zealand *Lochnagrostis* by Edgar (1995) show a wide range of palea to lemma length ratio from 0.50–0.95. Current measurements of 2–4 specimens (Appx. 1) of taxa with the shortest paleas, gave ranges in palea to lemma length ratio of 0.50–0.70 for *L. piloso* (Buchanan) Edgar, 0.63–0.66 for *L. leptostochys* (Hook.f.) Zotov, 0.60–0.78 for *L. lyallii* and 0.81–0.88 for *L. striato* (Colenso) Zotov. Current measurement of the lemma and palea of specimens of *Agrostis bergiano* and *A. continuota* (Appx. 1) resulted in palea to lemma length ratio of 0.76 and 0.35, respectively, and confirmed reported values (Table 2).

It therefore appears that neither the presence of a rachilla extension or palea to lemma length ratio can be exclusively used to segregate all the South African taxa into current circumscriptions of *Agrostis* and *Lochnagrostis*.

Other gross morphological characters

Panicle form, lemma length and hairiness, awn length and attachment point, and anther length are often variable within and between genera, although some characters show a trend towards a common state within a genus (Table 2).

The panicle form for *Polypogon* is always contracted and spike-like (spiciform), though sometimes interrupted, while *Lochnogrostis* displays loosely contracted to open panicles. Panicles of *Agrostis* vary widely between taxa, from spiciform to open.

Lemma length varies so widely within genera (Table 2), that it does not serve well as a discriminating character between them.

The lemmas of all Australasian *Agrostis* taxa are glabrous and smooth, whereas the lemmas of the majority of *Lochnogrostis* are hairy to some extent or finely scaberulous in part (although there are exceptions) (Table 2). This general rule also applies to *Agrostis* (and to *Polypogon*) in the northern hemisphere, with a few exceptions in *A. conina* L. and *A. vineolis* Schreb. with their minutely pubescent bases and in *A. costellono* Boiss. & Reut. with its occasional hairs in the lower half (Harvey 2007). Many species are also observed to sometimes display scabridulous or scabrous lemmas (e.g. *A. elliottiana* Schult., *A. howellii* Scribn. and *A. rossioe* Vasey). A further group of Himalayan to Chinese *Agrostis* (including *A. pilosulo* Trin., *A. pendryi* Paszko, *A. griffithiono* (Hook.f.) Bor and *A. munroona* Aitch. & Hemsl.) are unusual in having lemmas covered in pilose hairs (Shenglian & Phillips 2006; Paszko 2014). Among the South African *Agrostis*, *A. eriantha*, *A. suavis* and *A. polypogonoides* have moderately to very hairy lemmas, as do *L. borbuligera*, *L. schlechteri* and *L. lachnantha*. The original description of *A. huttonioe* (as *Colamagrostis huttoniae* (Hack.)) by Hackel (1905) indicated that the lemma is glabrous, whereas later descriptions of a hairy lemma (e.g. Launert 1971) may be referrable to *L. lachnontha* when treated in synonymy. Stapf (1897) described *A. continuota* as being pilose along the secondary nerves of the lemma, while the lemmas of *A. natolensis* are presumably glabrous.

Almost all Australasian *Lochnagrostis* have lemma awns (albeit that some are greatly reduced) whereas only a quarter of Australasian *Agrostis* taxa (*A. boormanii* Vickery, *A. magellonico* Lam., *A. oresbio* Edgar, *A. petriei* Hack. and *A. venusto* Trin.) regularly have lemmas with a basal to mid-dorsal awn. A number of other species occasionally have very fine to early deciduous lemma awns. For North America, Harvey (2007) notes about a third of the endemic species to have regularly awned lemmas and a further third to be sometimes awned. Substantial lemma awns are found in the South African *A. continuoto* and *A. natalensis* (arising from the lower dorsal region) and *A. eriantha* and *A. suovis* (arising from the mid-dorsal region) and in the South American *A. montevidensis* (arising from the upper-dorsal region). The remaining *Agrostis* taxa are awnless or have insubstantial awns. Within *Lochnogrostis* only *L. lochnantho* (like *A. huttonioe*) has an occasional minute sub-terminal lemma awn. All *Polypogon* taxa have sub-terminally awned lemmas, except for *P. viridis*, but the awns range from being long, robust and twisted in *P. tenellus* R.Br. to minute in *P. griquensis*.

Anther length in *Agrostis* and *Lachnagrostis* varies considerably (Table 2), although all the South African taxa (where known), other than *L. lachnantha*, have anthers of at least 1 mm. The anthers of *Polypogon* tend to be 0.5 mm or less. Descriptions of anther length in *P. strictus* are lacking but current measurements (Appendix 1) ranged from 0.3–0.7 mm.

Lemma epidermis features

Björkman (1960) described a common lemma epidermis feature of *Agrostis* as a 'trichodium net': 'where the beams of two laterally adjacent cells alternate, resulting in a fine-meshed network over the surface of the lemma'. He developed a 4-fold categorisation: 1) network fully developed, 2) network only fragmentarily developed, 3) without a developed network but with a tendency toward it and 4) entirely without a network or tendency toward it. Widén (1971) utilised the trichodium net in his work with *Agrostis* in eastern Fennoscandia but introduced additional categories, related to the relative thickness of the cell walls, to make a 7-fold system. Jacobs (2001), when describing the lemmatal epidermal structure of the Australian *Agrostis*, *Lachnagrostis* and *Deyeuxia* in comparison to *Calamagrostis*, also used the trichodium net pattern but only described three types: i) the trichodium net pattern, ii) 'raised margins of epidermal cells, with or without prickles', and iii) 'a comparatively smooth epidermis, the cell walls appearing more or less wavy in outline but the margins flush with the surface, prickles present or absent and macrohairs present or absent'. The 'raised margins' pattern (ii) of Jacobs (2001) is probably comparable to the 'without a developed network' but 'a tendency toward' (iii) of Björkman

SEM images of basal lemma surfaces show distinctive trichodium net patterns for *A. bergiana*, *A. continuata*, *A. montevidensis* and all the tested Australasian *Agrostis* taxa (Fig. 1a–c, e–h). This is in keeping with most *Agrostis* species in other parts of the world, as reported by Björkman (1960), Widén (1971) and Finot et al. (2011) among others (e.g. *A. canina* L., *A. tenuis* Sibth. (syn. *A. capillaris* L.) and *A. rupestris* of Europe; *A. hyemalis* (Walt.) B.S.P. and *A. idahoensis* Nash of North America; *A. inaequiglumis* Griseb. and *A. rigidula* Steud. (syn. *A. infirma* Buse.) of Asia, *A. brachyathera* Steud. and *A. ramboi* Parodi of South America and *A. dyeri* Petrie and *A. petriei* Hack. of New Zealand). As *A. canina* is the type of *Agrostis*, the presence of a trichodium net should be taken as the typical state for the genus. Notable exceptions are the widely introduced *A. stolonifera*, *A. castellana* and *A. gigantea* (Fig. 1d), which have either fragmentary (as in the first two species) or only a tendency (as in the last species) for trichodium networks. Interestingly, taxa with under-developed trichodium networks tend to have higher palea to lemma length ratio and may represent species divergence from *Agrostis* to *Polypogon*, *Lachnagrostis* or other Agrostidinae genera. On the other hand, a group of African taxa, including *A. bergiana*, show trichodium networks on the palea as well as on the lemma (Björkman 1960) but also have a relatively long palea. Superficially, *A. bergiana* is similar to *A. stolonifera* which also has an erect or ascending habit, a contracted panicle, relatively long paleas and anthers and a diminutive awn (if present) and is suggestive of a close relationship. However, the distinctive differences in lemma epidermis structure between the two taxa would indicate otherwise.

All of the tested Australasian (Fig. 2e–h) and South African *Lachnagrostis* (Fig. 2a–b), except for *L. barbuligera* (Fig. 3a–b), show an absence of a trichodium net, even though there are some differences in the epidermis between species. In addition, the South African *A. polypogonoides* and *A. eriantha* also lack a trichodium net (Fig. 2c–d).

Björkman (1960) found that *Polypogon* species (including *P. monspeliensis* and *P. semiverticillatus*), lacked a trichodium network on their lemma epidermis, while species of *Chaetotropis* did possess a trichodium net. The lack of such a network in the recent SEM images of *A. semiverticillata* and *A. griquensis* (Fig. 3g–h) confirms their non-*Agrostis* status and supports their placement in *Polypogon* as *P. viridis* and *P. griquensis*, respectively. Jacobs (2009) considered *P. viridis* to belong in *Agrostis*, which may be explained by his erroneous comment that *A. viridis* 'has a classic *Agrostis* spikelet, including the trichodium net ... and the characteristic lemma surface of *Agrostis* s. str'.

Discussion

Agrostis natalensis and *A. continuata*

Clayton (1970) considered *Agrostis natalensis* to be synonymous with *A. continuata* Stapf of Malawi along with *A. radula* Mez of Malawi and *A. makoniensis* Stent

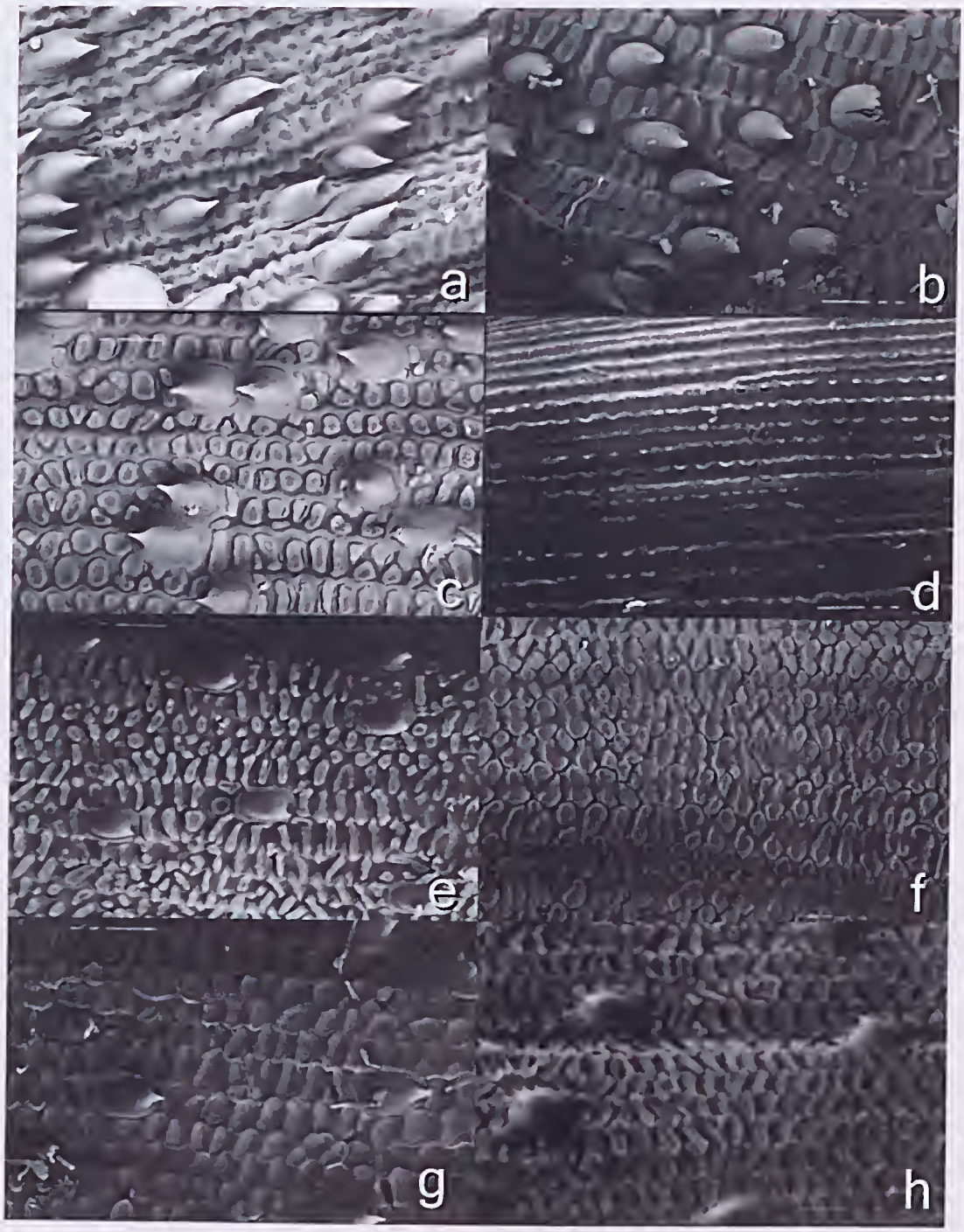

Figure 1. Scanning Electron Microscope images (×1800) of the lower lemma epidermis of *Agrastis* from South Africa and Australasia: **a.** *A. bergiana* (SJi); **b.** *A. natalensis* (SJi); **c.** *A. mantevidensis* (SJi); **d.** *A. gigantea* (SJii); **e.** *A. venusta* (SJi); **f.** *A. parviflara* (SJi); **g.** *A. australiensis* (SJi); **h.** *A. prapinqua* (SJi). See Table 3 for voucher information; SJ = Jacobs pattern classification.

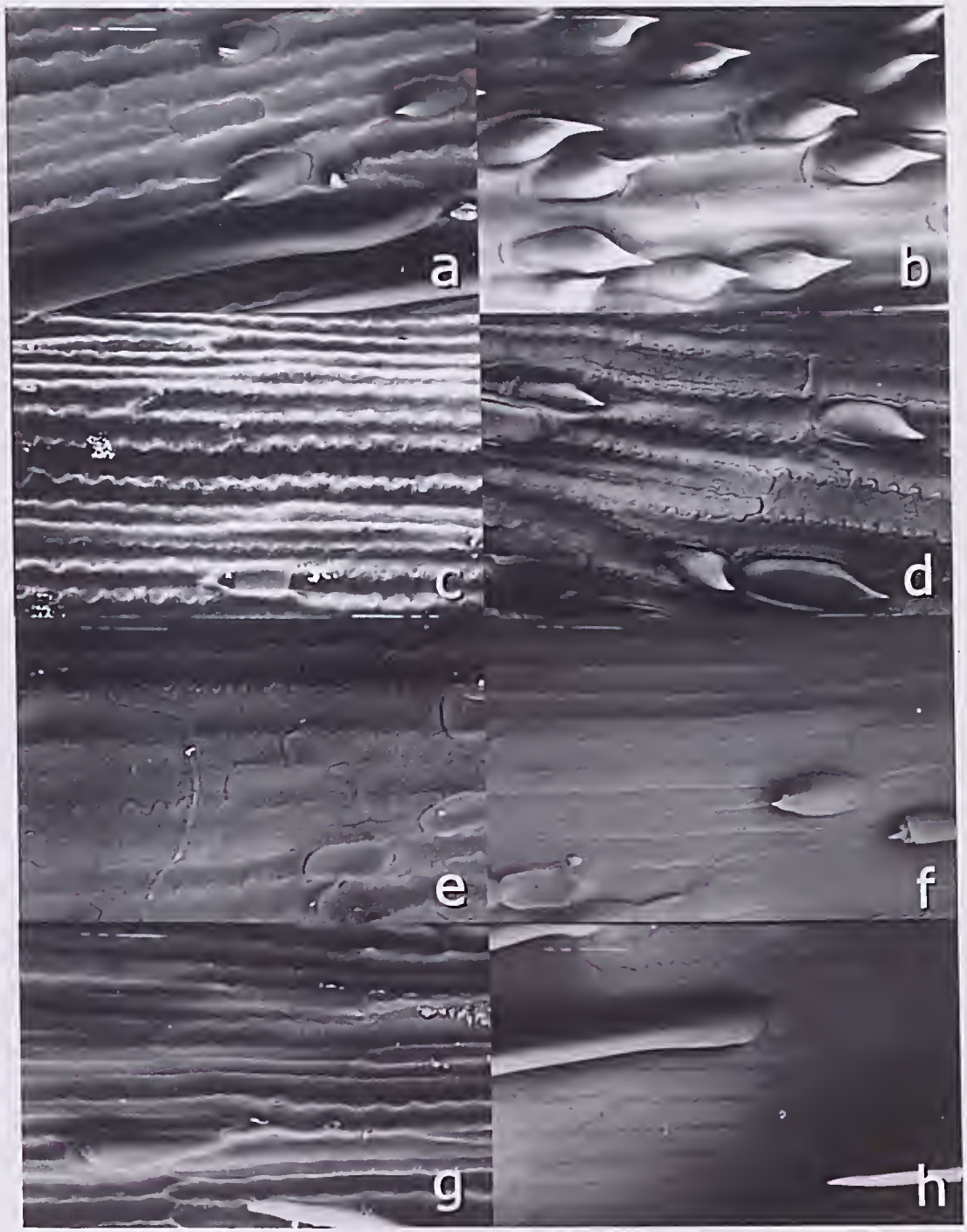

Figure 2. Scanning Electron Microscope images (×1800) of the lower lemma epidermis of *Lochnagrostis* taxa from South Africa and Australasia: **a.** *Agrostis lochnontho* (syn. *Lochnogrostis lachnontho*) (SJii); **b.** *A. schlechteri* (syn. *L. schlechteri* (SJiii); **c.** *Agrostis suavis* (syn. *L. eriantho*) (SJii); **d.** *A. polypogonoides* (syn. *L. polypogonoides*) (SJiii); **e.** *A. odomsonii* (syn. *L. odomsonii*) (SJiii); **f.** *A. avenaceo* (syn. *L. filiformis*) (SJiii); **g.** *A. meionectes* (syn. *L. meionectes*) (SJii); **h.** *A. oemula* (syn. *L. oemulo*) (SJiii). See Table 3 for voucher information; SJ = Jacobs pattern classification.

& Rattray of southern Rhodesia (Zimbabwe), and Launert (1971) included *A. whytei* C.E.Hubb. of Malawi in synonymy. However, Hubbard (1937) considered that *A. natalensis* could be distinguished from *A. continuata* by its 5- or 6-noded culms (compared to 2- or 3-noded), its larger spikelets (5.3–6.4 mm in length compared to 4.2–5.3 mm) and its linear-oblong glumes (compared to oblong). Stapf (1897) described the lemmas of *A. continuata* as being thinly pubescent along the nerves, but did not do so for *A. natalensis*. Other differences between the taxa are the longer paleas, awns and anthers and generally higher awn attachment of *A. continuata* (Table 2). The production of a rachilla extension from 0.5–4 mm long, appears common for *A. continuata* but is missing for *A. natalensis*.

Unusually for *Agrostis* (and *Lachnagrostis*), both taxa have erect, spike-like, lobed panicles with branches in dense, oblong fascicles, lemma nerves that extend beyond the apex into fine mucros and a robust, scabrid, straight to subgeniculate, lemmatal awn that tapers at both ends (see Plate 195 in Wood 1904). Apart from these features, the presence of a trichodium net on the lemma epidermis indicates that they do not belong in *Lachnagrostis*. Stapf (1897) comments that *A. natalensis* is allied to the Malagasy *A. elliotii* Hack., the subantarctic *A. antarctica* Hook. f. (syn. *A. magellanica* Lam.) and a few South American species described by Nees von Esenbeck (1841a) under *Bromidium*. Future detailed study of this group of grasses may dictate one or more separate genera to *Agrostis*.

Lachnagrostis lachnantha (syn. *Agrostis lachnantha*), *A. huttoniae*, *A. neesii* and *A. papposa*

Although rachilla extensions are generally absent in *Lachnagrostis lachnantha*, the taxon conforms to *Lachnagrostis* in spikelet size, lemma hairiness, and palea to lemma length ratio. The closely related *Agrostis huttoniae* does have a rachilla extension, although Launert (1971) considered that this feature and the longer callus hairs described by Goossens and Papendorf (1945) could not be used to separate the two taxa, as he found many intermediate stages between them. However, as it is sufficiently different from *L. lachnantha* in its larger glumes (3 mm compared to 1.6–2.6 mm), lemmas (2.5 mm compared to 1.5–2 mm) and anthers (1 mm compared to 0.5–0.8 mm), in addition to the presence of a rachilla extension, it should be considered as both a separate species and as a species of *Lachnagrostis*.

Trinius (1841) made the new combination *A. neesii* Trin. for the South African *Podosemum angustum* Nees but treated it as synonymous with *A. lachnantha* (syn. *P. lachnanthum* Nees). Nees von Esenbeck (1841b) described these taxa as similar but different in a number of features. These included, for *P. angustum*: 'i.e. flosculo glabro mutico' (glabrous, awnless lemmas) and 'i.e. processu calli distincto lineari barbato' (distinct and shortly bearded, rachilla extension) and for *P. lachnanthum*: a lemma with 'i.e. apice bidenticulata infra apicem brevissime setuligera calloque villosis' (short bristle arising from between two short teeth at the apex, surface villous hairy) and 'i.e. calli processu nullo aut obsoleto' (rachilla extension absent or minute). In these characters, *P. angustum* (syn. *A. neesii*) appears very similar to *A. huttoniae* and may represent the same entity. However, the herbarium specimen (MEL2386775) examined as *A. neesii* (Appendix 1) had a hairy lemma and lacked a rachilla extension and therefore appeared to conform to *L. lachnagrostis*. Note that the herbarium specimen (NSW883631) identified as *A. neesii* from which the lemma epidermis SEM image derived (not shown), and with a trichodium net, is actually a collection of *A. bergiana*, according to duplicate sheets at PRE and GRA examined by Goossens and Papendorf (1945).

Although Goossens and Papendorf (1945) placed the South African *A. papposa* Mez in synonymy with *A. huttoniae*, its position is not as clear. Mez (1922) describes it as having 'i.e. axis processus certe deest' (rachilla extension certainly missing), spikelets of 2.2 mm length and glabrous lemmas ¾ the length of the glumes (i.e. 1.7 mm). Apart from the glabrous lemmas and the 'i.e. callus ... pilis longis papposa' (callus a long haired pappus, compared to the Stapf (1900) description of 'callus scantily bearded' for *A. lachnantha*), this taxon more nearly approaches *L. lachnantha* than *A. huttoniae*, but remains taxonomically uncertain until a more thorough examination can be made.

The lemma of *L. lachnantha* is distinct from the other South African *Agrostis/Lachnagrostis* taxa in only being 3-nerved. Almost all other *Agrostis* and *Lachnagrostis*, worldwide, have 5-nerved lemmas, except sometimes in a few species, including *A. capillaris*, *A. castellana*, *A.*

gigantea, *A. elliotiana* and *A. nipponensis* and in some Malagasy taxa (Edgar & Forde 1991; Clayton et al. 2006 onwards; Harvey 2007, Jacobs & Brown 2009). In some cases, the five nerves are somewhat indistinct and may lead to a description of only three or four.

Lachnagrostis schlechteri, *Agrostis suavis*, *A. eriantha* and *A. polypogonoides*

The presence of a rachilla extension, the high palea to lemma length ratio and the lack of a trichodium network on the lemma epidermis of *Lachnagrostis schlechteri* confirms its current generic placement. The last two characteristics, at least, indicate that *Agrostis suavis* and *A. polypogonoides* also belong to *Lachnagrostis*.

Goossens and Papendorf (1945) noted *A. polypogonoides* as having 'rachilla produced', even though Stapf (1900) noted 'rachilla not produced beyond the floret', in his original description. Hackel (1904) described *A. eriantha* as having 'rachilla non producta'. Current examination of herbarium specimens of both taxa (Appendix 1), found no evidence of a rachilla extension. Despite the lack of a rachilla extension, *A. eriantha* and *A. polypogonoides* display all the other main characters of *Lachnagrostis*, including diffuse panicles, large spikelets, hairy lemmas and geniculate awns.

After 'carefully' examining the types of *A. eriantha* and *A. suavis*, both morphologically and anatomically, Goossens and Papendorf (1945) concluded that they belong to the same species. However, they did not mention the difference in the presence or absence of a rachilla extension. On the other hand, as the illustration of the type for *A. suavis* in Wood (1908) does not feature a rachilla extension and the text indicates 'rachilla reduced to a fascicle of hairs scarcely ½ line [ca. 1 mm] long', such could easily have been overlooked.

In their observation of leaf anatomy across all the types and co-types of South African *Agrostis*, Goossens and Papendorf (1945) mention that *A. eriantha* was an exception in having a leaf that is 'fairly rigid and typically folded so that it appears ellipsoid or V-shaped when seen in cross section', but whether or not *A. suavis* was also found to be an exception is not stated. In the original descriptions by Hackel (1904) and Stapf (1908), respectively, the leaves of *A. eriantha* are 'i.e. plerumque complicatae' (mostly folded), while those of *A. suavis* are 'i.e. ex siccando plicate' (folded on drying out). However, without more distinct differences, it is probable that the two taxa are indeed the same species.

A SEM image of the lemma epidermis of *A. eriantha* (*N.J. Devenish 3843* (PRE664945) – not shown) was found to be almost identical to that of *A. suavis* (Fig. 2c).

Lachnagrostis barbuligera

Although *Lachnagrostis barbuligera* has the gross morphological characters of the other South African *Lachnagrostis*, it has a trichodium net on its lemma epidermis (Fig. 3a and *Jacot-Guillamod 3737* (PRE40497) – not shown). Björkman (1960) noted that a group of montane tropical African grasses, including *Agrostis alpicola* Hoschst. and *A. sclerophylla* C.E.Hubb. from Abyssinia (Ethiopia), *A. burttii* C.E.Hubb. from the Belgian Congo, *A. dissitiflora* C.E.Hubb., *A. friesiorum* C.E.Hubb., *A. keniensis* Pilg., *A. mildbraedii* Pilg. *A. pilgeriana* C.E.Hubb., *A. trachyphylla* Pilg. and *A. volkensii* Stapf from Kenya and *A. kilimandscharica* Mez and *A. producta* Pilg. from Tanganyika (Tanzania), had long paleas (at least two-thirds the length of the lemma) and a trichodium net pattern (although fragmentary in the case of *A. pilgeriana*) on both their lemma and palea epidermes. Clayton (1970) treated *A.burttii* and *A. friesiorum* as synonymous with *A. kilimandscharica*; *A. alpicola* and *A. mildbraedii* as synonymous with *A. quinqueseta* (Steud.) Hochst.; and *A. dissitiflora* as synonymous with *A. gracilifolia* C.E.Hubb. Within this group, Phillips (1986) also identified *A. mannii* (Hook.f.) Stapf from highlands of the Cameroon and Fernando Po and *A. diffusa* S.M.Phillips from Ethiopia. The current study confirms a trichodium net pattern on the lemmas of *A. kilimandscharica* (Fig. 3c as *L. burttii*), *A. trachyphylla* (Fig. 3d) and *A. quinqueseta* (as *A. mildbraedii* – not shown).

Like *A. barbuligera*, the spikelets of most of these grasses also have a rachilla extension, tend to have pilose lemmas and basal or near-basal lemma awns. They therefore form a group of species that are distinct from both *Agrostis* and *Lachnagrostis*. If future phylogenetic work finds that they form a distinct clade, the old generic name of *Anomalotis* Steud., for which *Anomalotis quinqueseta* Steud. (syn. *Agrostis quinqueseta*) is the type species, could be used.

Unlike the typical subspecies, *Agrostis barbuligera* var. *longipilosa* has never been transferred to *Lachnagrostis*.

It is morphologically similar to *L. schlechteri*, with the lemma awn attachment point being the major difference. However, the awn of *A. barbuligera* var. *longipilosa* is often adhered to the lemma back from the base to the mid-point, which can appear to be its attachment point. From the limited specimens examined (Appendix 1), *L. schlechteri* appears to have acute, rather than acuminate glumes, the lemma apices are not as drawn out into fine setae and the lemma hairs are dense and straight, to 0.5 mm long rather than being scattered and somewhat wavy, to 1 mm long, as for *A. barbuligera* var. *longipilosa*. Unlike *L. schlechteri* (Fig. 2b), examination of the lemma epidermis of *A. barbuligera* var. *longipilosa* shows that it, like var. *barbuligera* (Fig. 3a), also has a trichodium net pattern (Fig. 3b).

Agrostis bergiana, *A. aristulifera* and *A. subulifolia*

These three entities may represent the same taxon, but without a range of specimens to examine, such cannot be assessed at this time. Gibbs Russell et al. (1990), Clayton et al. (2006 onwards) and POSA (2009) recognised *Agrostis bergiana* and *A. subulifolia*, at least, as separate taxa. As for typical *Agrostis*, all three taxa lack a rachilla extension and at least *A. bergiana* and *A. aristulifera* have a lemma epidermis with a trichodium net (Fig. 1a; Björkman 1960). However, their palea to lemma length ratios are more akin to *Lachnagrostis* or *Polypogon*, and at least *A. bergiana* also displays a trichodium net on the palea.

Björkman (1960) notes that these taxa are similar to the *A. kilimandscharica* group from tropical Africa, except that most of the latter have strongly awned, pilose lemmas and a rachilla extension. The closest matches to *A. bergiana* from this group are *A. sclerophylla* and *A. pilgeriana* with which it shares the characters of a mid to upper dorsal lemma awn (rather than a basal awn), and a lack of a rachilla extension. Both *A. bergiana* and *A. sclerophylla* have glabrous lemmas. Further examination, and, more particularly, genetic assessment, may prove whether these grasses are part of the *A. kilimandscharica* group or not. What is clear from the current analysis is that they cannot be considered to belong to *Lachnagrostis*.

Polypogon monspeliensis, *P. strictus* and *P. tenuis*

These taxa have always been considered to be species of *Polypogon*, since *P. monspeliensis* was segregated from *Alopecurus* by Desfontaines (1798), by its awned glumes and lemma. The South African *P. strictus* and Ascension Island *P. tenuis* also have this feature. Björkman (1960) noted that both *P. monspeliensis* (Transcapian, *Sintenis 1773* (UPS)) and *P. tenuis* (South Africa, *Alcock 6635* (S)) lack a trichodium net on their lemma epidermis. The current study confirms this feature for *P. monspeliensis* (Fig. 3e), at least.

Whether *P. strictus* and *P. tenuis* are the same taxon or not is beyond the scope of the current paper. Contemporary opinion (Goldblatt & Manning 2000; Raimondo et al. 2009) appears to be that they are not the same, and therefore any reference to *P. tenuis* in South Africa (e.g. Björkman 1960), should be applied to *P. strictus*.

Polypogon griquensis (syn. *Agrostis griquensis*)

This taxon was considered to be an *Agrostis* until 1990, because of its lack of awns on the glumes. The same is true of *Polypogon schimperiana* (Hochst. ex Steud.) Cope, a grass from tropical Africa, which was not recognised as a *Polypogon* until 1995. Cope (1995) noted that a stipitate spikelet falling whole from the pedicel (or part of the pedicel) was a more defining character for *Polypogon* than the presence of awned glumes. The current study shows the lemma epidermis of both *P. schimperiana* (Fig. 3f) and *P. griquensis* (Fig. 3g) without a trichodium net pattern and confirms that they do not belong to typical *Agrostis*.

Polypogon viridis (syn. *Agrostis verticillata*)

The placement of the cosmopolitan *Agrostis verticillata* (syn. *A. viridis* Gouan, *A. semiverticillata* (Forssk.) C.Chr.) has always been problematic. Although the taxon has generally been recognised in the modern era as having spikelets that disarticulate below the glumes and therefore *Polypogon*-like, its lack of terminally awned glumes has kept it in *Agrostis* (as *A. semiverticillata*) in a number of floras e.g. Hitchcock (1951), Hubbard (1968), Rotar (1968), Willis (1970), Hitchcock and Cronquist (1973), Gould (1975), Barkley (1986) or as *A. viridis* in

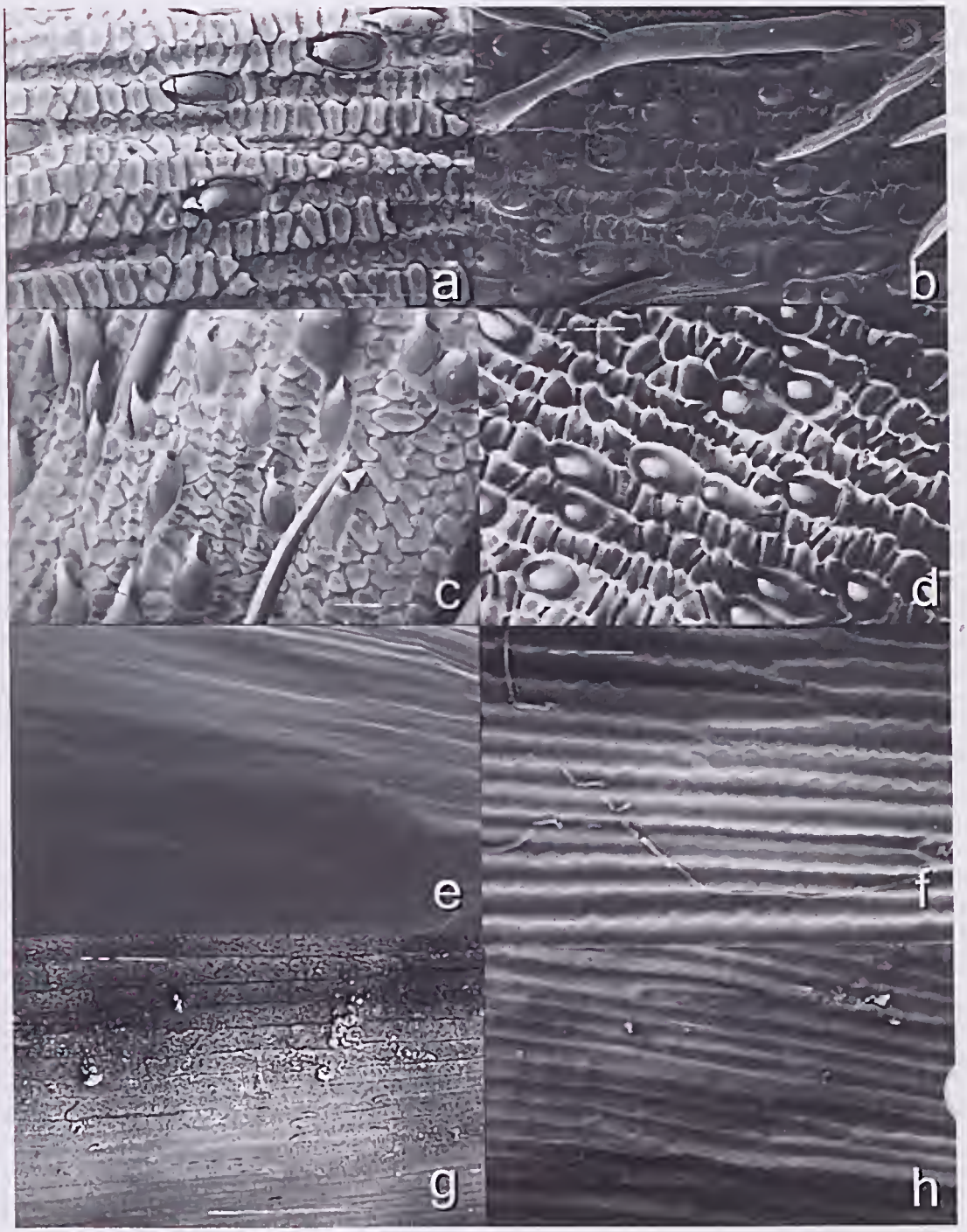

Figure 3. Scanning Electron Microscope images (×1800) of the lower lemma epidermis of *Agrostis* taxa from South and East Africa and *Palypagan* taxa: **a.** *A. barbuligera* var. *barbuligera* (syn. *L. barbuligera*) (SJi); **b.** *A. barbuligera* var. *langipilasa* (SJi); **c.** *A. burttii* (syn. *A. kilimandscharica*) (SJi); **d.** *A. trachyphylla* (SJi); **e.** *Palypagon manspeliensis* (SJiii); **f.** *A. schimperiana* (syn. *P. schimperiana*) (SJii); **g.** *A. griquensis* (syn. *P. griquensis*) (SJiii); **h.** *A. verticillatus* (syn. *P. viridis*) (SJii). See Table 3 for voucher information; SJ = Jacobs pattern classification.

Jacobs (2009). Floras that listed the taxon as *Polypogon semiverticillatus* include Correa (1978) and Tsvelev (1984), and as *P. viridis* include Jessop and Toelken (1986), Gibbs Russell et al. (1990), Walsh and Entwisle (1994), Sell and Murrell (1996) and Edgar and Connor (2000). In the current study, the lack of a trichodium net on the lemma epidermis (Fig. 3h) confirms the taxon's placement in *Polypogon*, rather than in *Agrostis*.

Taxonomy

Three South African *Agrostis* taxa are transferred to *Lachnagrostis* and new combinations made. Without having ready access to the range of type specimens, lectotypification of these names has not been attempted.

Lachnagrostis eriantha (Hack.) A.J. Br., **comb. nov.**

Agrostis eriantha Hack. *Vierteljahrsschr. Naturf. Ges. Zürich* 49: 172 (1904).

Types: **SOUTH AFRICA.** Pretoria, Gauteng Province, *R. Schlechter 4144*, 6.i.1894 (syntype: W19160036234; isosyntypes: BM000922815, FR0030125, K000367406, MPU027097, PRE0592110-0, US00156418 (Cat. No. 75384), Z000073069); Middleburg, Eastern Cape, *R. Schlechter 4052*, 22.xii.1893 (syntype: W19050007172; isosyntype: BM000922816, K000367405, US01164502 (Cat. No. 3449125), Z000073070).

Agrostis eriantha var. *planifolia* Gooss. & Papendorf. *S. African J. Sci.* 181 (1945). *Type:* SOUTH AFRICA. Irene, Doornkloof, Transvaal, *Pole-Evans 666*, 3.xii.1922 (holotype: PRE0038905-0).

Agrostis suavis (Stapf.), *Bull. Misc. Inform. Kew* 1908: 227 (1908). *Type:* SOUTH AFRICA. Van Reenen, Natal, *Wood 8913*, 29.i.1903 (K000367407, K000367408, K000367409, NH0009346-0, NH0009975-0, W19160037226).

Examined specimens: see Appendix 1.

Note: One examined collection (*Davidson 33256 & Mogg* PRE38890) has completely glabrous lemmas (except for the callus). Otherwise it seems to conform to *Lachnagrostis eriantha*. Wood (1908) describes *L. suavis* as having lemmas 'laxly clothed with fine hairs on the back' but surprisingly his illustration (Plate 497) appears to have glabrous lemmas. In addition, the lemma awns in his illustration appear about 1–1.5× as long as the lemmas, whereas the original description indicates awns 1.5–1.7× lemma length.

Lachnagrostis polypogonoides (Stapf) A.J.Br., **comb. nov.**

Agrostis polypogonoides Stapf. *Fl. Cap. (Harvey)* 7: 549 (1900).

Type: **SOUTH AFRICA.** Muizenburg Vlei, Western Cape, *Wolley Dod 2349*, 9.i.1897 & ii.1897 (BM000922820, BOL139282, BOL139283, BOL139284, K000367375).

Examined specimens: see Appendix 1.

Note: *Polypogon polypogonoides* (Stapf) Forsan is not a validly published name: 'Forsan' being Latin for 'perhaps' and presumably intended as a comment on the identity of the specimen rather than as an authority of a new combination (Vorontsova & Simon 2012).

Lachnagrostis huttoniae (Hack.) A.J.Br., **comb. nov.**

Calamagrostis huttoniae Hack. *Rec. Albany Mus.* 1(5): 340 (1905); *Agrostis huttoniae* (Hack.) C.E.Hubb. ex Gooss. & Papendorf. *S. African J. Sci.* 41: 179 (1945).

Type: **SOUTH AFRICA.** Shafton, Howick, Natal, 17.xii.1901, *H. Hutton 384* (holotype: W19160037833; isotypes: BOL139281, GRA0000153-0, K000367395, US00157149 (Cat. No. 75386), W19160036845).

Note: No specimens of this taxon have been examined but the published descriptions suggest sufficient differences to maintain it as a separate species from *Lachnagrostis lachnantha*. Closer study may show otherwise.

Agrostis lachnantha var. *glabra* Gooss. & Papendorf was regarded by Gibbs Russell et al. (1990) as 'not distinct'. For the same species, Victor et al. (2012) noted that 'hairs on the lemma are variable in length and cannot reliably be used to distinguish varieties'. Victor et al. (2012) also regarded callus hair length, used to distinguish *A. eriantha* var. *planifolia* Gooss. & Papendorf, as 'not a reliable character'. Because of the uncertainties related to the distinctiveness of these varieties, they have not been transferred to *Lachnagrostis* at this time. The variation observed for a number of South African *Lachnagrostis* in the current study suggest that further fieldwork and examination of a wider range of material is required and may facilitate the recognition or reduction of additional taxa in the future.

Conclusions

The native South African Agrostidinae segregate into four distinct morphological groupings:

1. *Agrostis natalensis* and/or *A. continuata* – contracted panicle with fasciculated branches, spikelet disarticulation above the glumes, short palea relative to lemma, glabrous to near glabrous lemma, trichodium net present on lemma epidermis, with or without rachilla extension.
2. *Agrostis barbuligera* and *A. bergiana* (probably incl. *A. subulifolia*) (with strong affinities to the *A. kilimandscharica* /*A. mannii* group of tropical montane Africa) – open to loosely contracted panicle, spikelet disarticulation above the glumes, long palea relative to lemma, hairy or glabrous lemma, trichodium net present on lemma epidermis, with or without rachilla extension.
3. *Lachnagrostis lachnantha*, *L. huttoniiae*, *L. schlechteri*, *L. eriantha* and/or *L. suavis* and *L. polypogonoides* – open to loosely contracted panicle, spikelet disarticulation above the glumes, long palea relative to lemma, usually hairy lemma (glabrous in *L. huttoniiae*), trichodium net absent on lemma epidermis, with or without rachilla extension.
4. *Polypogon strictus* and *P. griquensis* – spiciform to densely contracted panicle, spikelet disarticulation below the glumes, long palea relative to lemma, glabrous lemma, trichodium net absent on lemma epidermis, without rachilla extension.

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Appendix 1: Specimens of *Polypogon* (MEL), *Agrostis* (MEL, PRE) and *Lachnagrostis* (AK, CHR) examined for comparison with published descriptions

Polypogon monspeliensis

SOUTH AFRICA. In ausgetrockente Walleien (sumpfigte Stelle) an Zwartkopsrivier (i.e. Blackcap River) 1:e Höhe (Distr. Uitenhage), xii.1829, [*C.F. Ecklon*] *1828* (as 854 *Setaria* [U. J.] No.969) [probably equivalent to *P. polysetus* Steud.] (MEL2386787); *J.F. Drège a*, ex hrb Sonder (as *P. strictus* (*P. monspeliensis* var. *pallens*)) [Isosyntype of *P. monspeliensis* var. *pallens* Nees from Olifantrivier fluvium (i.e. Elephants River Valley) near Ebenezar (Nees von Esenbeck 1841b)] (MEL2386783); near Grahamstown [Brand Kraal (Stapf 1900)], *P. MacOwan 1281* (MEL2386788). **AUSTRALIA.** Fish Creek Rail Station, Victoria, 5.xii.1994, *A. Paget 1148* (MEL2026751) [SEM image].

Polypogon strictus

SOUTH AFRICA. 2–11 [Uitenhage, Zwartkopsrivier, Villa Paul Maré to Uitenhage – November (Gunn & Codd 1981)], [*C.F. Ecklon & K.L.P. Zeyher* in part] taxon 59, ex hrb Sonder [probably *P. strictus* var. *major* Nees] (MEL2386786, MEL2386789); 78 [Cape Doornhogde (Gunn & Codd 1981)], [*C.F. Ecklon & K.L.P. Zeyher*], ex hrb Sonder [probably *P. strictus* var. *minor* Nees] (MEL2386784); *J.F. Drège*, ex hrb Sonder (as *P. strictus* var. *spelaeus*) [Isotype of *P. strictus* var. *spelaeus* Nees from a cave on the Witt Bergen at 6000' with *Podosemum lachnanthum* var. *humile*, Tulbagh, Western Cape (Nees von Esenbeck 1841b)] (MEL2386785); Chapman's Peak, Cape Peninsula, xii.1919, *H. Andreae 114* (as *P. tenuis* ex PRE) (MEL2386782).

Notes: Most of the specimens of *Polypogon* above have no clear collector and location information, but examination of the literature has enabled these details to be identified. The three specimens of *P. strictus* ex hrb Sonder (MEL2386786, MEL2386784, MEL2386785) were found in the same folder at MEL, along with the specimen of *P. monspeliensis* ex hrb Sonder (MEL2386783). It seems that the earliest plant collectors in South Africa (Zeyher 1822–1842, Ecklon 1823–1828, Drège 1826–1834) initially considered any indigenous *Polypogon* population to be of *P. strictus* Nees., rather than of the European *P. monspeliensis* Desf., as *P. strictus* often appears on their collection sheets of the latter taxon. Nees von Esenbeck (1841b) described three varieties of *P. monspeliensis*: 'α Maior' syn. *P. polysetus* Steud., 'β Minor' syn. *P. monspeliensis* var. *capensis* Steud. and 'γ Pallens', and three varieties of *P. strictus*: 'α Maior', 'β Minor' and 'γ Spelaeus' for South Africa. Although only the one MEL specimen of *P. strictus* has a varietal name attached (i.e. var. *spelaeus*), the other two specimens conform to the descriptions of var. *major* and var. *minor*.

Steudel (1829) used the numbers 968 and 969 to designate *P. monspeliensis* and *P. polysetus*, respectively. These taxon numbers appear to be the same as used by the Unio Itineraria (U. J.), a botanical exchange club, founded and managed by E.G. Steudel and C.F. Hochstetter (Gunn & Codd 1981). For example, the label of the type of *P. polysetus* (S14-34076 image seen) notes 'U. J. *Ecklon*' and the number '969' but bears the location 'An feuchten Stellen der 2:e Höhe des Löwenberges (i.e. Lion Mountains)'. Steudel (1829) described the type location as 'In paludosis altitudinis 2 montis dorsei leonis'. A duplicate of MEL2386787 (including the same label details) is also at S (S14-34067 n.v.). The number '854' for *Setaria* appears to be a taxon number which was mistakenly applied to MEL2386787, probably as an original label, due to the superficial likeness of the panicles of *Setaria* and *Polypogon* in the field. Steudel (1829) also noted '*Setaria*' for collections of *P. monspeliensis* and *P. polysetus*, presumably describing original label inscriptions.

The numbers 2–11 (or 2.11) and 78 are codes for Ecklon and Zeyher's collection localities (Gunn & Codd 1981): the 11 referring to the month of sampling. An identical *P. strictus* label to MEL2386789 bearing the number 59 and the locality – month code 2.11 is attached to the Missouri Botanical Garden Herbarium sheet (MO-2397264 image seen), even though the specimen has been since determined as *P. monspeliensis*. As the number 60 and the locality code 85 [eastern side of Table Mountain at Constantia (Gunn & Codd 1981)] is associated with a label on a further South African specimen of *P. monspeliensis* at MO (MO-2397263 image seen), it appears that the numbers 59 and 60 are also taxon numbers (separate to those of Steudel 1829 and Ecklon & Zeyher 1834), rather than collection numbers or location codes.

Agrostis griquensis (syn. *Polypogon griquensis*)

SOUTH AFRICA. Bloemfontein, near Tempe farm, Free State, 6.x.1917, *Geo. Potts 2467* (MEL2386781) [NSW duplicate imaged by SEM – see Table 3].

Agrostis semiverticillata (syn. *Polypogon viridis*)

SOUTH AFRICA. Umbilo River, Durban, KwaZulu-Natal, *C.J. Word 5948* (MEL2386779); Erigaro, Bristish Somaliland, 29.v.1939, *A.S. McKinnon s.n.* (MEL2386780).

Agrostis bergiana

SOUTH AFRICA. Table Mountain, Western Cape, December, *C.F. Ecklon* (as 943) ex hrb. Sonder (MEL2386774) [Isotype of *A. ecklonis* Trin. typified by L. Pignotti (W) 2010].

Note: A number of authorities (e.g. Tropicos 2015; JSTOR 2015) note 943 as Ecklon & Zeyher's collection number for *Celastrus heterophyllus* Eckl. & Zeyh. when in fact, Ecklon and Zeyher (1834) list it as the taxon number for this species. However, 943 was also used to designate *A. capensis* Steud. (syn. *A. bergiana*) in the distribution of specimens by the Unio Itineraria. Steudel (1829) appears to have mistakenly listed the taxon number for *A. capensis* as 493 (when all the surrounding grass taxon numbers are in the 900s).

Agrostis continuata

SWAZILAND. Near Mbabane: valley of Black Mbuluzi River, i.1965, *K.D. Gordon-Gray 65/102* (MEL2323539).

Agrostis barbuligera* var. *barbuligera (syn. *Lachnagrostis barbuligera* var. *barbuligera*)

SOUTH AFRICA. Holmes Farm, portion Vredesrus, NNE of Maclear, North-eastern Cape, 31.x.1994, *S.P. Bester 3074* (PRE835477); Estcourt, KwaZulu-Natal, 21.xi.1940, *Curotor Pretorio E909* (PRE38936). **LESOTHO.** Top of Organ Pipes Pass, Cathedral Peak, 26.i.1978, *L. Smook 1081A* (PRE513672); Reed's Camp, Tschlangana Valley, Basutoland, 8.i.1960, *Jocot-Guillormod 3737* (PRE40497) [SEM image]; Schlabathebe National Park, Ntloana-Tsoana, 13.xii.1977, *F.K. Hoener 1907* (MEL2323525).

Agrostis barbuligera* var. *longipilosa

SOUTH AFRICA. Bethlehem, Free State, 24.i.1965, *B.R. Roberts 3280* (PRE38919) [SEM image]; Steenkampsberge, Mpumalanga, 7.xii.1983, *L. Smook 4826A* (PRE670162); 14 km van Sabie na Graskop, Mpumalanga, 24.x.1988, *J. Sooymon 76* (as *Agrostis lachnontha*) (PRE742515). **SWAZILAND.** Forbes Reef Road, Mbabane, 1.xi.1957, *R.H. Compton 27192* (PRE38923); Lydenberg na Sabie, Mpumalanga, 24.x.1988, *J. Soayman 57* (PRE742618); Pilgrims Rest, Mpumalanga, 15.xii.1975, *P.C.V. Du Toit 1071* (PRE3S6993); Wakkerstroom, Free State, 20.xi.1962, *N.J. Devenish 951* (PRE104231).

Agrostis eriantha

SOUTH AFRICA. Tafelkop, Wakkerstrom, Oshoek, Free State, 1982, *N.J. Devenish 3843* (PRE664945) [SEM image]; Bethlehem, Free State, 1.i.1963, *L.C.C. Liebenberg 7017* (PRE40503); New Scotland Special, Athole, P.R. Station, Ermelo, Mpumalanga, 10.ii.1943, *L.E.W. Codd 392* (PRE38909); Athole Pasture Research Station, Mpumalanga, 11.i.1936, *C.M. Norval 122* (PRE38897); Crown Mines Marsh, Johannesberg, 11.iii.1965, *L. Dovidson 33256 & A.O.D. Mogg* (PRE38890).

Agrostis avenacea (syn. *Lachnagrostis filiformis*)

SOUTH AFRICA. McGregor, Riviersonderendberge, Western Cape, 16.x.1988, *J.J. Spies 3922* (PRE742585); Barrydale, Tradouw Pass, Western Cape, 13.x.1981, *L. Smook 3756* (PRE60879S); Emberton Farm, Knysna , Western Cape, 24.xi.1980, *A.O. Crook 2334* (PRE610390); Graskop na Bosbokrand, Northern Province, 24.x.1988, *J. Saoymon 78* (PRE742615).

Agrostis lachnantha (syn. *Lachnagrostis lachnantha*)

SOUTH AFRICA. NW of Olifantshoek in Langeberge, Western Cape, 10.viii.2000, *L. Smook 10950* (PRE588744); Langs Modderrivier Glen, Bloemfontein, Natal, 31.i.1986, *J.J. Spies 2662* (PRE671808); Cathedral Peak Park, Baboon Rock, KwaZulu-Natal, 21.xii.1988, *H. Du Plessis* 99 (PRE741413); Anne's Hoek, Buffelskloof Nature Reserve, Lydenberg, Mpumalanga, 10.xii.2004, *J.E. Burrows 8673* (PRE770789); Monte Boschberg, Western Cape, *P. MocOwan 1667* ex hrb Sonder, (MEL2371711); *J.F. Drège o*, ex hrb Sonder (as *Podosoemum lochnonthum* var. *humile* Nees), (MEL2371712); Willow Grange, KwaZulu-Natal, x.1905, *J. Medley Wood* 9942 ex hrb Natal (MEL2386776); Rooidraai farm, Lydenburg, Mpumalanga, 7.xii.1935, *L.C.C Liebenberg 3491* ex PRE (MEL2386777); 1.12 [Worchester, Waterfall, 1-2000', December (Gunn & Codd 1981)] [*C.F. Ecklon & K.L.P Zeyher*], taxon 61 [isosyntype of *Podosemum lochnonthum* Nees (Nees von Esenbeck 1841b)] (MEL2386778); *unknown*, ex hrb Sonder (as *Agrostis neesii* (*Podosaemum* [*Podosemum*] *ongustum* Nees)) (MEL2386775).

Note: Some of the early specimens at MEL have few details attached. However, a search of the literature has managed to locate much of the missing data. See notes under *Polypogon strictus* above for explanations of locality codes and taxon numbers.

Agrostis polypogonoides

SOUTH AFRICA. Lokenberg, Northern Cape, 24.i.1954, *Acocks 17580* (PRE40478); Villiersdorp, Western Cape, 8.i.1896, *R. Schlechter 3797* (PRE38861).

Agrostis schlechteri (*Lachnagrostis schlechteri*)

SOUTH AFRICA. Suurvlakte, Paarl, South-west Cape, 9.ii.1947, *E.E. Esterhuysen 13727* (PRE40537); Stellenbach, Cape Province, xii-i.1947, *L. Visser PRE35059* (PRE40540).

Lachnagrostis leptostachys

NEW ZEALAND. Antipodes Is., 8.i.1909, *unknown* (CHR333324); De La Vire, Campbell Is., 7.i.1961, *Zotov s.n.* (CHR119513).

Lachnagrostis lyallii

NEW ZEALAND. Wapiti Lake, 12.iii.1985, *Platt s.n.* (CHR521641); cult. ex Tongariro National Park, 3.iii.1971, *P.J. de Lange 5203* (AK252979).

Lachnagrostis pilosa* subsp. *pilosa

NEW ZEALAND. Isolation Ck., Waima River, xii.1979, *Druce s.n.* (CHR363565); Cape Palliser, Wairarapa, xii.1973, *Druce s.n.* (CHR273108); Lake Wakatipu, xii.1991, *Druce s.n.* (CHR475873); Bold Peak, *Simpson s.n.* (CHR370168).

***Lachnagrostis striata*:**

NEW ZEALAND. Kaweka Lakes, xii.1964, *Druce s.n.* (CHR131763); Makinkiri Tarus, ii.1981, *Druce s.n.* (CHR389436).

Muelleria

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A new species *Grevillea burrowa* (Proteaceae) from the Burrowa-Pine Mountain National Park, North Eastern Victoria

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Abstract

Grevillea burrowa Molyneux & Forrester sp. nov. is described, illustrated and mapped. This new species is only known at present from two adjoining ridgetops and upper slopes c. 3 km apart in the Burrowa-Pine Mountain National Park in north-eastern Victoria. Its relationships with *Grevillea oxyantha* subsp. *oxyantha* Makinson, *G. oxyantha* subsp. *ecarinata* Makinson and *G. brevifolia* F.Muell. ex Benth. are discussed, as are regional geomorphology, distribution and habitat, etymology and conservation status. The species is assessed as critically endangered on the basis of extreme geographic restriction and projected risk from fire, climatic drying and recruitment failure.

Keywords: Proteaceae, *Grevillea victoriae* complex, morphology, taxonomy, Australia

Introduction

The *Grevillea victoriae* complex remained, until recently, one of the most challenging unresolved complexes in the third largest genus in the Australian flora. The predominantly montane distribution of the complex in south-eastern Australia, with many populations confined to ridges, upper slopes and plateaux, has predisposed the complex over time to natural fragmentation and consequent exposure to strong founder effects, genetic drift and localised selection pressures.

The taxonomic status and affinities of two stands of *Grevillea* allied to members of this complex on the Burrowa Plateau in north-eastern Victoria have remained unresolved and not accounted for by earlier treatments of the complex (McGillivray & Makinson 1993; Makinson 1997, 2000; Molyneux & Stajsic 2000; Stajsic & Molyneux 2006; Stajsic 2010).

Recent studies in *Grevillea oxyantha* Makinson subsp. *oxyantha* demonstrate considerable regional character variation over its wide and diverse habitat range on high montane sites and the southern near-coastal ranges within the Southern Tablelands botanical division of NSW and the ACT. Makinson (1997), having already erected *G. oxyantha* subsp. *ecarinata* Makinson within this complex, suggested that further studies of populations within *G. oxyantha* subsp. *oxyantha* may necessitate recognition of additional subspecies to accommodate this diversity.

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Makinson (pers. comm. to WMM) has suggested that it may also be necessary to undertake further studies of *G. oxyantha* subsp. *ecarinata*, due to the range of critical characters that have been more closely studied since this subspecies was named.

While we agree that further investigation of both subspecies is required, clarification of variation within, and the conspecific status of, the two subspecies as currently circumscribed is beyond the scope of this paper. It has been necessary, however, to include critical comparison of character state differences between the two subspecies of *G. oxyantha* and the Burrowa Plateau entity, as it had been suggested that this entity could be included within the circumscription of *G. oxyantha* subsp. *ecarinata* (Stajsic pers. comm.). We do not accept this opinion and provide morphological data to support our hypothesis that the new entity represents a distinct species which we describe below as *Grevillea burrowa*.

Affinities and evolution

A comparison of character states of available extant populations (Table 1) indicates the close morphological proximity of *G. oxyantha* subsp. *oxyantha*, *G. victoriae* F.Muell. subsp. *nivalis* Stajsic & Molyneux and *G. oxyantha* subsp. *ecarinata*. Further, shared character states between *G. oxyantha* subsp. *oxyantha*, *G. brevifolia* F.Muell. ex Benth. and *G. burrowa* indicate a close relationship between these taxa.

The presence in at least some plants of a subacute floral limb face within *G. burrowa* (but not in *G. brevifolia*) suggests that this character state may be derived from the subpyramidal floral limb of *G. oxyantha* subsp. *oxyantha*, a singularly important and defining diagnostic character for this subspecies. Modifications of the pyramidal floral limb are also present in populations of *G. oxyantha* subsp. *ecarinata*.

The geographic and genetic isolation of the Burrowa Plateau population from other closely related taxa in niche habitats at higher elevations has resulted in *G. burrowa* being a relatively uniform entity with a distinctive suite of character states exhibiting some variation in the percentages of floral rachis branching and in the shape of the face of the floral limb between or within subpopulations. *Grevillea burrowa* is a biogeographically isolated and morphologically distinct taxon (see Fig. 2) represented by many thousands of individual plants. We recognise it here at species rank.

Figure 1. *Grevillea burrowa*, illustrating the subacute perianth limb face often found in plants sympatric with plants with an obtuse perianth limb face

Table 1. Summary of major diagnostic characters of *Grevillea burrowo* and allied taxa within the *G. victorioe* complex. Where character states show bimodal distributions within or between populations the lower and higher ranges are provided.

	Grevillea burrowa	*Grevillea brevifolia*	*Grevillea oxyantha* subsp. *oxyantha*	*Grevillea oxyantha* subsp. *ecorinota*	*Grevillea victoriae* subsp. *nivalis*	*Grevillea victoriae* subsp. *brindabella*
Branchlet shape and indumentum	biconvex or subterete, often with spaced longitudinal ridges, becoming terete, densely subsericeous	terete or subterete, longitudinally ridged, becoming terete, moderately to densely subsericeous or subtomentose	biconvex or subterete, becoming terete, longitudinally ridged in some races, densely tomentose or subsericeous	biconvex, eventually subterete or terete, subsericeous	biconvex, becoming terete, densely subsericeous or subtomentose	biconvex, angular with several longitudinal ridges, subterete or terete, densely sericeous or subsericeous
Leaf upper surface indumentum and venation	initially openly subsericeous, becoming so only along prominent raised mid and lateral veins, imparting a 'silvery' appearance to plants, eventually glabrous, dullish green	initially densely sericeous or subsericeous, becoming glabrous, dull or shiny green, mid and lateral veins level with or below leaf surface, evident or obscure	initially with openly curling villous or subsericeous hairs, becoming glabrous, dull or shiny green, mid and lateral veins level with or marginally below leaf surface, often obscure	initially openly subsericeous, soon nearly glabrous, dull green, mid and lateral veins level with or marginally recessed in leaf surface, obscure	initially with scattered, appressed silvery-white hairs, becoming glabrous, mid to dark green, mid and lateral veins conspicuous, reticulum obscure to conspicuous, usually evident	semi-glossy or distinctly glossy, glabrous but for sericeous hairs just above petiole, lateral veins raised, evident to conspicuous, reticulum absent
Leaf lower surface indumentum and venation	densely sericeous or rarely subsericeous, mid and lateral veins raised, obvious, reticulum irregular or absent, epidermis obscured	densely sericeous or subsericeous, mid and lateral veins evident or obscure, reticulum absent, epidermis obscured or partially visible	densely tomentose, subtomentose, curling villous or rarely subsericeous, mid and lateral veins raised, evident, reticulum evident in some races, epidermis obscured or partially visible	tomentose, subtomentose or subsericeous, mid and lateral veins raised, evident or obscure, reticulum evident or obscure, epidermis obscured or partially visible	densely subsericeous or subtomentose, mid and lateral veins raised, evident, reticulum conspicuous, rarely obscure or absent, epidermis not visible	densely sericeous or subsericeous, epidermis not visible, lateral veins evident or obscure, reticulum absent
Leaf shape	oblong to broadly oblong-acute or ovate obtuse, c. 30% of leaf bases strongly or weakly oblique	elliptic, narrowly elliptic, ovate or obovate, leaf bases not oblique	broadly ovate, elliptic or suborbicular, c. 18% of leaf bases weakly oblique (as low as c. 3% in some races)	ovate, elliptic, broadly elliptic or lanceolate, c. 2% of leaf bases weakly oblique	elliptic, narrowly elliptic, ovate, lanceolate or oblanceolate, leaf bases not oblique	usually narrowly to broadly lanceolate, occasionally ovate or elliptical, leaf bases apparently not oblique
Leaf length x width	(25-)42 & 76-80(-106) mm x (16-)30-34 & 56 (-60) mm	(8-)21-38(-49) mm x 6-16(-20) mm	(11-)20-30 & 60(-70) mm x (10-)14 & 36(-39) mm	(12-)46-66(-116) mm x (6-)17-36(-48) mm	(20-)35-100(-135) mm x (7-)15-37 mm	(20-)40-60(-85) mm x (5-)12-18(-32) mm
Conflorescence branching	simple 58-69% 1 branched 16-22% 2 branched 10-12% 3 branched 3-4%	simple 77% 1 branched 21% 2 branched 2%	simple 82-90% 1 branched 9-17% 2 branched 1-3%	simple 30% 1 branched 42% 2 branched 20% 3 branched 8%	simple 43% 1 branched 47% 2 branched 8% 3 branched 2%	simple 50% 1 branched 32% 2 branched 18%
Length of primary peduncle	(0-)2-4 & 8-10(-12) mm	(0-)3-7(-11) mm	(0-)4-5 & 8-12(-14) mm	0-50 mm	0-35 mm	(0-)4-15 mm

Table 1 cont. Summary of major diagnostic characters of *Grevillea burrowo* and allied taxa within the *G. victorioe* complex. Where character states show bimodal distributions within or between populations the lower and higher ranges are provided.

	Grevillea burrowo	*Grevillea brevifolia*	*Grevillea oxyontha* subsp. *oxyontha*	*Grevilleo oxyontho* subsp. *ecorinata*	*Grevilleo victorioe* subsp. *nivolis*	*Grevilleo victorioe* subsp. *brindabella*
Number of flowers per unit conflorescence	(6-)12-18 & 24(-30)	(14-)20-22(-30)	(5-)10-16(-22)	(6-)20-32(-62)	16-68	(20-)38-50(-64)
Floral rachis length and indumentum	(10-)12-20(-32) mm subsericeous	(7-)15-20(-35) mm subsericeous	(6-)8-13(-24) mm tomentose or shortly villous	(12-)20-45(-60) mm subsericeous or subtomentose	8-60 mm densely subsericeous	(14-)25-50(-60) mm, sericeous or subsericeous
Posture of juvenile buds in relation to decurved floral rachis	reflexing to c. 90°	reflexing to c. 90°	most buds reflexing >90°	some buds reflexing >90° in some populations as they mature	reflexing to c. 90°	reflexing to c. 90°
Perianth limb shape and size prior to tepal separation	transversely elliptical, rarely subglobose in side view, face obtuse or subacute (see Fig. 1), midline keeling absent or obscure, 3.8-4.2 mm across, 3.4-4 mm deep in side view	subglobose, midline keeling absent or obscure, c. 3 mm across and deep in side view N.B. the subacute face of the floral limb in collections from west of Mearangaah (Merriangaah) Peak (Costin, NSW 93308) is inconsistent with all other collections of G. brevifolia	acutely to bluntly subpyramidal, squarish face-on with ± straight angles, keeling strongly defined along midline, 3-3.5 mm across at base, 5-6 mm deep in side view	subpyramidal or irregularly subglobose with a short nipple-like contraction present in some populations, midline keeling absent or evident, 2-2.8 mm across, 2.2-3.2 mm deep in side view	subglobose, midline keeling absent, 2.3-2.5 mm across, 2.2-2.4 mm deep in side view	round in side view, squarish face-on, obtuse or slightly subacute, midline keeling obscure to evident, 2.2-2.5(-3.0) mm across, 1.5-1.8 mm deep in side view
Perianth outer surface, size and indumentum below limb	body roundish or squarish in cross section, 18-23 mm long, 3.3-3.8 mm across at widest point near base, 2.2-2.5 mm across at the midpoint, densely subsericeous, hardly constricted below the limb, epidermis red-pink, dorsal tepals 25-28 mm long	body squarish in cross section, 18.5-23 mm long, 2.3-2.8 mm across at widest point near base, 2-2.5 mm across at the midpoint, openly tomentose or subtomentose, clearly constricted below the limb, epidermis red-pink, dorsal tepals 21-24 mm long	body squarish in cross section, 18-25 mm long, 1.8-2.2 mm across at widest point near base, 1.6-1.8 mm across at the midpoint, densely subsericeous to shortly subtomentose, clearly constricted below the limb, epidermis red-pink or occasionally creamy white, dorsal tepals 22-27 mm long	body squarish in cross section, 18-25 mm long, 1.8-2.5 mm across at widest point near base, 2-2.2 mm across at the midpoint, subsericeous, villous or subtomentose, clearly to hardly constricted below the limb, epidermis pink or red-pink, dorsal tepals 22-28 mm long	body squarish in cross section, 22-25 mm long, 2.5-4 mm across at widest point near base, 2.5-3 mm across at the midpoint, tomentose or subtomentose, clearly constricted below the limb, epidermis red or red-pink, dorsal tepals 16-19 mm long	body squarish in cross section, 16-19 mm long, 2.4 mm across at widest point near base, moderately to densely subsericeous, hardly constricted below the limb, epidermis red or reddish-pink, dorsal tepals 17-22 mm long
Ovary and follicle hairs*	always present on ovary and follicle	always absent	always absent	always absent	always absent*	sometimes present on ovary*, absent on follicle

*Note that Stajsic (2010) inadvertently transposed the character states for ovary hairs between *Grevillea victoriae* subspp. *nivalis* and *brindabella*.

Taxonomy

Grevillea burrowa Molyneux & Forrester **sp. nov.**

Diagnosis: *Differs from Grevillea brevifolio in having prominently raised venotion on upper and lower leaf surfaces, longer ond wider leoves, lorger perionth limb ond perionth wider ot widest point, densely subsericeous ond hordly constricted below the limb. Differs from G. oxyontha subsp. oxyontho in having prominently roised venation on upper leof surfoce, juvenile buds reflexing only to c. 90°, perionth limb which is tronsversely ellipticol or rorely subglobose, shorter ond wider ond not strongly keeled, ond a distinctly wider perionth. Differs from oll other members of the G. victoriae complex excepting G. victoriae subsp. brindobello with which it shares the unique chorocter of hairs present on the ovary which, in this species, ore retoined ot maturity.*

***Type*: AUSTRALIA, VICTORIA.** Burrowa-Pine Mountain National Park. On the Burrowa Walking Track c. 1.5 km N by foot from the junction of the Mount Burrowa Walking Track with Hinces Walking Track. On ridgeline and c. 150 metres down NNW slopes, 1.56 km SE of Mount Burrowa. 28 October 2002. 36° 06′ 03″ S 147° 42′ 28″ E; Alt. 1143 m, *V. Stajsic 3314, W. Molyneux, S. Forrester, P. Ashton ond H. Merkel.* On broad rhyolite N-S running ridge line and down NW slopes. Holotype: MEL 2190712A and MEL 2299595 (same collection, comprising a dry sheet and spirit, respectively); Isotypes: AD, BRI, CANB, HO, NSW, K, NY, WELT.

Spreading *shrub* 1.5–4(–6) m high, 2–4(–7) m wide. *Branchlets* biconvex to subterete, often longitudinally ridged, becoming terete, densely subsericeous, white with a scattered overlay of tan hairs. *New growth*

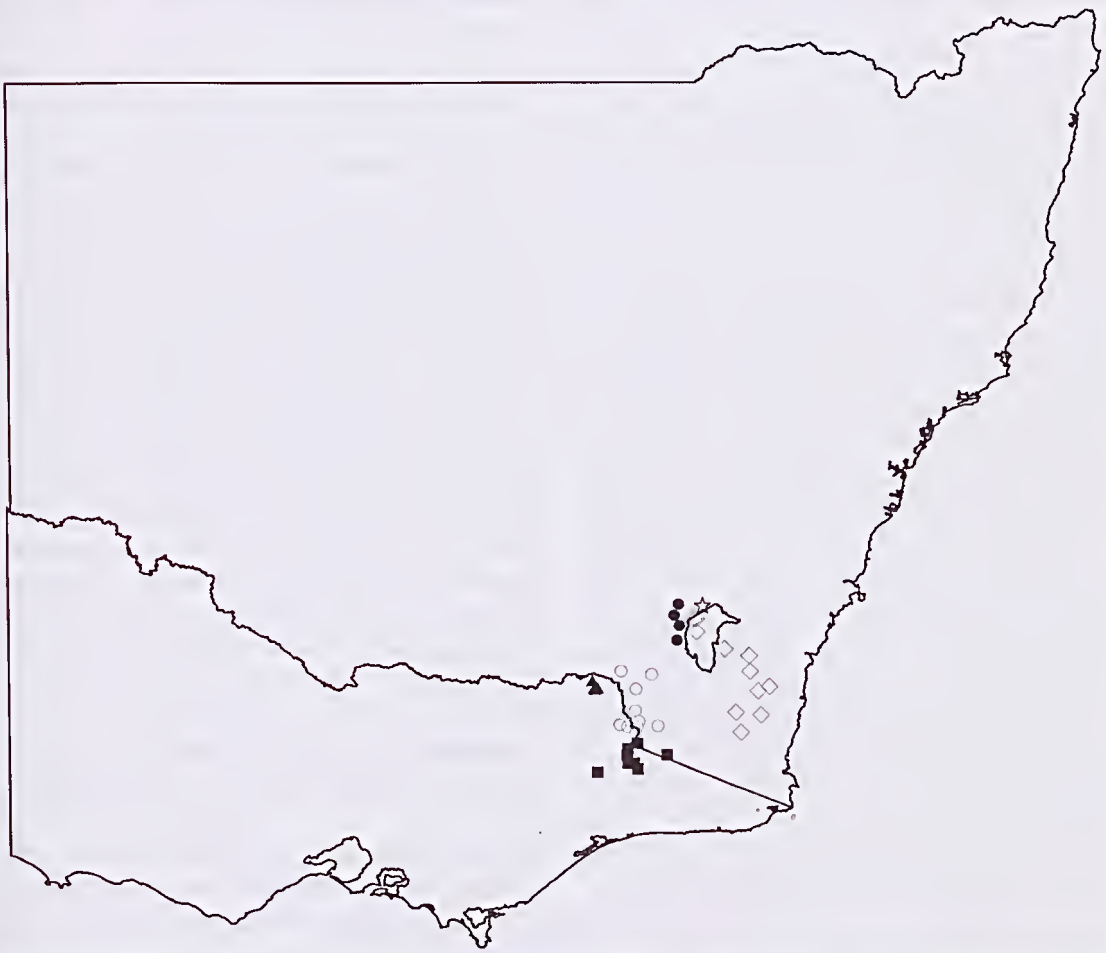

Figure 2. Distribution of *G. brevifolia* (square); *G. burrowa* (triangle); *G. oxyantha* subsp. *ecarinata* (closed circle); *G. oxyantha* subsp. *oxyantha* (diamond); *G. victoriae* subsp. *nivalis* (open circle); *G. victoriae* subsp. *brindabella* (star)

red-purple (RHS 1986 ed. 60c) for c. 3-4 leaves. *Leaves* petiolate, oblong to broadly oblong-acute or ovate, obtuse, c. 30% of leaf bases strongly or weakly oblique, dimensions bimodal: (25–)42 & 76–80(–106) mm long, (16–)30–34 & 56(–60) mm wide; *margins* recurved; *upper surface* initially with tan hairs then silky white subsericeous, imparting a silvery appearance to plants, soon confined mainly to raised mid and lateral veins, becoming ± glabrous, dullish green; *lower surface* densely sericeous or rarely subsericeous, with or without scattered light brown hairs on raised mid and lateral veins, reticulum irregular or absent, epidermis obscured. *Conflorescence* terminal, axillary or occasionally ramiflorous, declined, decurved or seldom pendulous, simple to branched, simple = 58–69%, one branched = 16–22%, two branched = 10–12%, three branched = 3–4%; *primary peduncles* (0–)2–4 & 8–10(–12) mm long (0.8–)1.2(–1.6) mm wide with a dense white subsericeous indumentum with scattered tan hairs; *ultimate peduncles* (0–)3–4, 7–8 & 12(–14) mm long, (0.8–)1.3(–1.8) mm wide with a dense white subsericeous indumentum with a second open overlay of tan hairs; *unit conflorescence* shortly conico-cylindrical, acropetalous; *floral rachises* (10–) 12–20(–32) mm long, 0.8–1.2 mm wide; *number of flowers per unit conflorescence* (6–)12–18 & 24 (–30); *pedicels* c. 5 mm long; *floral bracts* sigmoidal in side view, narrow, margins strongly recurved, c. 3 mm long, 0.6 mm wide at base, 0.3 mm wide at apex. *Immature buds* subglobose, obtuse or subapiculate, reflexed at or less than c. 90° to rachis. *Perianth of mature pre-anthesis flowers* roundish in cross-section below limb, midline keeling absent or, if squarish, then with rounded angles and keeling obscure or absent, c. 18–23 mm long, 3.3–3.8 mm across basally, 2.2–2.5 mm across at mid-point, hardly restricted below limb; *dorsal tepals* 25–28 mm long; *outer surface* below limb red-pink, hardly visible beneath hairs, indumentum dense, consisting of a lower layer of pale silky subsericeous simple hairs and an overlay of light tan and brown or red-brown subsericeous hairs; *inner surface* light pink, dorsally bearded with dense silky hairs commencing 2.5 mm above toral rim and extending for 6 mm, ventral beard commencing 6 mm above toral rim and extending for 5 mm. *Torus* oblique at c. 40 degrees, *nectary* broadly crescentic projecting 1.8–2.0 mm above rim of torus. *Pistil* 20–24 mm long, glabrous but for scattered simple white hairs on the ovary and style. *Stipe* of ovary 1.5–2.0 mm long. *Ovary* c. 4 mm long, green, with occasional simple white hairs proximally and dorsally. *Perianth limb prior to tepal separation* transversely elliptical, rarely subglobose, obtuse or subacute (Fig.1), nodding, squarish face-on, 3.8–4.2 mm across, 3.4–4.0 mm deep, in side view limb segments not or hardly keeled along midline, densely subsericeous with tan and brown hairs obscuring the epidermis. *Style* pink-red, exerted from dorsal suture, not strongly bowed prior to anthesis, nearly straight or lightly curved, deflexing anteriorly from ovary post-anthesis, 14–18 mm long, style end c. 4 mm long, 3 mm wide, with short scattered white hairs on the back of the style end and on upper style, face of pollen presenter concurrent with style, flat or marginally concave. *Follicles* narrowly and obliquely ovoid to obliquely ellipsoid, glabrous but for scattered, simple white hairs proximally, 18–20 mm long, 8 mm wide, 7 mm deep.

***Specimens examined*: VICTORIA: Eastern Highlands.** Mount Burrowa Walking Track from Hinces Saddle on a broad NNE aligned rhyolite saddle and upper NNW slopes occupying 2.1 ha at an elevation of 1143 m. 36°06'03"S, 147°42'28"E. 1.x.2000. *W.M. Molyneux s.n., P. Ashton and K. Rule.* (MEL 2090949 (sheet) and MEL 2095073 (spirit), MEL 2090950); Burrowa-Pine Mountain National Park, north on NE ridgeline of early Palaeozoic rhyolite from Hinces Walking Track c. 200 m beyond Black Mountain summit parking area. Several thousand plants over c. 9 ha. Elevation 1198 m, 36°07'22"S, 147°43'03"E. 17.xii.2012 *W.M. Molyneux, S.G. Forrester and K. Goyne s.n.* (MEL 2371066); Burrowa-Pine Mountain National Park, northern steep bluff end of NE ridgeline off Hinces Walking Track from the Black Mountain summit parking area. Many thousands of plants over c. 12 ha. Elevation 1110 m, 36°05'49"S, 147°44'56"E. 10.xii.2013. *W.M. Molyneux and K. Goyne s.n.* (MEL 2376436); Burrowa National Park, 23.x.1987, *A.C. Beauglehole 89172, and L.W. Huebner* (MEL 2109083); Burrowa-Pine Mountain National Park, Range between Mount Burrowa and Lookout Rocks. xii.1978. *P.G. Smith* (DELWP Arthur Rylah Institute for Environmental Research, Heidelberg, Plant Reference Collection).

***Etymology*:** The epithet recognizes the collection of the type material on a walking track to Mt. Burrowa and also its location in the Burrowa-Pine Mountain National Park in north-eastern Victoria where it is apparently endemic. Unfortunately, due to the extinction of the local language groups (Luise Hercus pers. comm. 2013) the origin of the name Burrowa is not known from the Pallanganmiddang. Barry Blake (pers. comm. 2014)

indicated that Booroowah, the 'White Breasted Diver' in Dhudhuroa, was the closest traditional name that he could find to Burrowa. It is plausible that the 'White-breasted Sea-eagle', also known as the White-bellied Sea-eagle, which still feeds and nests along the Murray River and its tributaries, may be the bird referred to by the Pallanganmiddang and perhaps seen hunting in the vicinity of the present day Mt Burrowa.

Distribution, habitat and ecology: *Grevillea burrowa* is apparently endemic to the Burrowa Plateau in north-eastern Victoria (Fig. 2) where it is currently known only by two populations on adjoining ridgetops and upper slopes c. 3 km apart in the Burrowa-Pine Mountain National Park. The population from which the type collection was taken, comprising many hundreds of plants, is on the Mt Burrowa Walking Track and occupies c. 2.1 ha. The second population of many thousands of plants is on a ridgeline running north-east from Black Mountain where it is subdivided by a narrow rocky saddle into two stands c. 9 ha and 12 ha in extent respectively. The substrate is mid Palaeozoic rhyolite supporting impoverished shallow to skeletal soils.

Associated vegetation is consistently Montane Dry Woodland or Ecological Vegetation Class (EVC) 36 (DELWP 2015) with the species extending into Rocky Outcrop Shrubland/Rocky Outcrop Herbland Mosaic or EVC 73 on northern aspects. Associated species include *Acacia dealbata* Link, *A. lanigera* A. Cunn., *A. kettlewelliae* Maiden, *A. rubida* A. Cunn., *Asterolasia asteriscophora* (F.Muell.) Druce, *Boronia nana* Hook., *Brachyscome diversifolia* (Graham ex Hook.) Fisch. & C.A. Mey., *Bulbine bulbosa* (R. Br.) Haw., *Callistemon pallidus* (Bonpl.) DC., *Coprosma hirtella* Labill., *Dianella tasmanica* Hook f., *Eucalyptus chapmaniana* Cameron, *E. dalrympleana* Maiden, *E. dives* Schauer, *E. mannifera* Mudie, *E. pauciflora* subsp. *pauciflora* Sieber ex Spreng., *Grevillea jephcottii* J.H. Willis, *Kunzea parvifolia* Schauer, *K. peduncularis* F.Muell., *K. parvifolia* x *peduncularis*, *Leionema lamprophyllum* (F.Muell.) Paul G.Wilson, *Leptospermum micromyrtus* Miq., *Lomatia ilicifolia* R. Br, *Pelargonium australe* Willd. and *Persoonia chamaepeuce* Lhotsky ex Meisn.

Phenology: Flowering has been recorded in late winter, spring, summer and sporadically in early autumn. *Acanthorhynchus tenuirostris* (Eastern Spinebill), and *Lichenostomus penicillatus* (White-plumed Honeyeater) are the two most active nectar feeders recorded on *Grevillea burrowa* during the cooler parts of the day in late spring and early summer. The observed activity of nectarivorous birds suggests the species is primarily ornithophilous. The species is apparently an obligate seed regenerator.

Conservation status: We estimate the age class distribution to be ca. 15% veterans to 4-6 m height assumed to have germinated following the 1952 wildfire, ca. 50% mature plants of intermediate size and apparently representing a sequence of germination events independent of fire, and ca. 35% seedlings and juveniles. Very few dead older plants are evident. The overall impression is of a healthy regenerating population. It is important to note though, that there have not been any landscape scale fires in this section of the Burrowa-Pine Mountain National Park since 1952 (Kelton Goyne pers. comm.). A localized fuel reduction burn was carried out in 1994, but there is scant evidence of this now.

Area of occupancy (AO) is estimated at 23 ha and extent of occurrence (EO) is estimated at 4.5 square km. Total population is estimated at 2000-4000 mature individuals. There is no evidence to suggest significant decline in population size since European settlement nor any significant population size fluctuations. Projected climatic drying and increasing frequency of extreme high temperatures are expected to result in increased mortality through drought stress and increasing risk of severe fire events and recruitment failure to drought stress, repeat fire events resulting in reduced seed production and, potentially, increased risk of herbivory by the exotic deer *Cervus unicolor* (Sambar). Longevity is arguably well in excess of the inferred age of the current cohort of 60 years and is plausibly 80-100 years. Continuous recruitment between fire events demonstrably occurs as inferred by the observed size class distribution. However, since the species is fire sensitive, resulting in mortality of all severely burnt individuals of all age classes consumed by each major fire event, generation time is interpreted as the mean frequency of wildfires which resulted in mass episodic seed recruitment. Such fires are assumed to have been ignited by lightning strikes which are common across the Burrowa Plateau. Based on the inferred time since the last major fire in the area, fire interval is inferred to be in the range of 50–100 years. Projected decline in population size in the next century, due to factors

discussed above, is estimated to be at least 30%. The species is therefore assessed as critically endangered since it qualifies very confidently under the following IUCN (2001) criterion:

CR B1ab(iii)+2ab(iii)

and also qualifies very confidently as vulnerable under the following IUCN criteria:

VU A3ce; C1; D2.

Notes: This is only the second occasion that hairs on the ovary or follicle have been recorded for a member of the 'linearifolia group' sensu Makinson (2000). The only previous record was for *Grevillea victoriae* subsp. *brindabella* (Stajsic 2010). This character permits the key to members of the *G. victoriae* species complex provided by Stajsic and Molyneux (2006) to be modified, by the insertion of a zeroth couplet at the start and the addition of a final couplet, to accommodate both *G. burrowa* and the only other recent addition to the complex, *G. victoriae* subsp. *brindabella*, as follows:

0. Hairs absent on ovaries and follicles 1

0a. Simple or biramous hairs present on ovaries and sometimes also on follicles **28**

28. Hairs patent, simple, white, scattered on ovaries and follicles; branchlet indumentum densely subsericeous; leaf upper surface ultimately dullish green; leaves oblong to broadly oblong or ovate, (25-)42 & 76-80(-106) mm long, (16-)30-34 & 56 (-60) mm wide; flowers per unit conflorescence (6-) 12-18 & 24(-30) ..... ***G. burrowa***

28a. Hairs patent, simple or biramous, white, scattered on ovaries but absent on follicles; branchlet indumentum densely sericeous or occasionally subsericeous; leaf upper surface semi glossy or distinctly glossy; leaves usually narrowly to broadly lanceolate, (20-)40-60(-85) mm long, (5-) 12-18(-32) mm wide; flowers per unit conflorescence (20-)38-50(-64) ..... ***G. victoriae* subsp. *brindabella***

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Our thanks go firstly to Kelton Goyne, Senior Ranger for the Upper Murray Unit of Parks Victoria in Tallangatta who, following a request by one of us (WMM) in 2012 to examine a specific ridgeline in the Burrowa-Pine Mountain National Park to ascertain the presence of *G. burrowa*, was very successful in his search. During two subsequent field trips with Kelton, the known area of occupancy of *G. burrowa* in the park grew from c. 2.1 to c. 23 ha. Curation Co-ordinator at MEL, Catherine Gallagher, has cheerfully provided access on numerous occasions to particular collections to further our research, and facilitated the transfer of loan material to La Trobe University for the convenience of one of us (WMM). Alison Vaughan (MEL) very generously produced the distribution map at short notice, while Susan Hoebee and Alison Kellow of the La Trobe University Department of Ecology, Environment and Evolution have been welcoming and continually supportive of the research for this project by facilitating the transfer of loan material and by providing space, facilities and access for one of us (WMM). Former Ranger at the Tallangatta Parks Victoria office, Peter Ashton, initiated the research for this paper by bringing to our notice the type locality of *Grevillea burrowa* in 2000, and Val Stajsic accompanied the authors on the second and type material collecting trip. We also wish to thank two anonymous referees whose combined knowledge has enhanced certain aspects of this paper. Last but never least we thank David Cameron for his unequalled editorial assistance and guidance regarding conservation status assessment.

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Muelleria

34: 55–58

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ROYAL BOTANIC GARDENS VICTORIA

Verrucaria alborimosa, a new maritime lichen from Flinders Island, Tasmania

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Abstract

Verrucaria alborimosa P.M.McCarthy & Kantvilas (lichenized Ascomycota, Verrucariaceae) is described from coastal limestone in Flinders Island, Tasmania. A key is provided to the 12 marine and maritime species of *Verrucaria* in Australia.

Key words: taxonomy, distribution, coastal

Introduction

Seven intertidal species of *Verrucaria* Schrad. (lichenized Ascomycota, Verrucariaceae) are known from rocky seashores in Australia, where they are regularly subjected to wave or splash action: *V. halizoa* Leight., *V. corallensis* P.M.McCarthy, *V. maura* Wahlenb., *V. meridionalis* P.M.McCarthy, *V. microsporoides* Nyl., *V. striatula* Wahlenb. and *V. subdiscreta* P.M.McCarthy (McCarthy 2012). Four others are commonly or exclusively found in the supralittoral spray zone, *Verrucaria aucklandica* Zahlbr., *V. australiensis* P.M.McCarthy, *V. fusconigrescens* Nyl. and *V. prominula* Nyl. (McCarthy 2012), sometimes in association with more landward populations of *V. maura* and *V. subdiscreta*.

In this paper, *V. alborimosa* P.M.McCarthy & Kantvilas sp. nov. is reported from limestone in coastal heathland in the supralittoral of Flinders Island, Tasmania. A revised key is provided to the 12 marine and maritime *Verrucariae* in Australia.

Verrucaria alborimosa P.M.McCarthy & Kantvilas, sp. nov.

MycoBank No.: MB813033

Characterised by the very dark, subgelatinous, rimose-areolate and non-punctate thallus, small and inconspicuous perithecia with broadly clavate asci, comparatively long periphyses, a thin and predominantly hyaline excipulum and small, broadly ellipsoid ascospores.

Type: **TASMANIA**. Flinders Island, The Dock, 39°48'S, 147°52'E, alt. 10 m, on limestone in coastal heathland, *G.Kantvilas 303/14*, 21.iii.2014 (holotype: HO 573957).

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Thallus crustose, epilithic, determinate, c. 20–25 mm wide, 20–60(–80) µm thick, greenish black (somewhat darker when older and thicker, much paler when partially shaded), rimose to areolate; sterile areolae 0.12–0.3(–0.38) mm wide, usually plane, dull, angular or more rounded, smooth to minutely and shallowly uneven, commonly rimulose, becoming greener and subgelatinous when wetted, lacking black external and internal punctae, ridges or other pigmented markings; rimae 30–60 µm wide when dry, the whitish substratum commonly visible at their base. *Cortex* absent; mycobiont cells hyaline, hyphal and 3–4 µm wide, or paraplectenchymatous and 3–5 × 2–3 µm; basal cells of the thallus hyaline, more thick-walled than distal cells, 3–4 µm wide. *Algal cells* yellowish green to green, globose, scattered or clustered, not forming columns, 5–10(–12) µm wide. *Prothallus* not apparent. *Perithecia* moderately numerous, largely immersed or becoming semi-immersed, usually solitary, (0.17–)0.23(–0.31) mm diam. [(min.–)mean(–max.); $n = 20$], dull black, not overgrown by the thallus, or with a c. 10 µm thick layer of thallus which is visible only in section; post-mature perithecia becoming excavate to crateriform as the involucrellum and perithecial contents disintegrate. *Perithecial apex* smooth and rounded, or slightly uneven; *ostiole* inconspicuous or, more commonly, in a c. 20–30 µm wide apical depression. *Involucrellum* greenish black in thin section, extending down to excipulum-base level while spreading laterally at an angle of c. 45°, 40–50 µm thick at the apex, 20–30 µm thick near the base. *Centrum* depressed-ovate, 0.14–0.21 mm diam. *Subhymenium* 10–15 µm thick, hyaline. *Excipulum* 10–15 µm thick, hyaline at the sides and base, hyaline to greenish brown or medium grey-brown near the apex; cells 4–7 × 2–3 µm. *Periphyses* unbranched, 25–35(–40) × 1.5–2 µm. *Paraphyses* absent. *Hymenial gel* fleetingly I+ wine-red. *Asci* 8-spored, broadly clavate, 35–40 × 14–20 µm [$n = 15$]. *Ascospores* simple, hyaline, usually broadly ellipsoid, occasionally subglobose, massed in the ascus, (9–)12.5(–15) × (7–)8.5(–10) µm [(min.–)mean(–max.); $n = 62$]; contents finely granulose to clear and vacuolate. *Conidiomata* absent. (Fig. 1)

Distribution and habitat: This lichen is known only from the type collection on the western coast of Flinders Island, Bass Strait, where it grew on outcrops of Quaternary limestone in coastal heathland. The substratum is relatively soft and highly weathered, and in the actively eroding, sand-blasted cliff edge, lichens are few or absent. The new species instead occurred in more sheltered microhabitats, on low, flat rock plates in gaps among the low, wind-pruned shrubs. Associated species included *Buellia albula* (Nyl.) Müll.Arg., *Caloplaca jerramungupensis* S.Y.Kondr., Kärnefelt & Elix, *C. yorkensis* S.Y.Kondr. & Kärnefelt, *Catillaria polycarpa* (Müll.Arg.) Zahlbr., *Placynthium nigrum* (Huds.) S.F.Gray s. lat., *Sarcogyne* sp., *S. meridionalis* P.M.McCarthy & Kantvilas and *V. maura*.

Etymology: The epithet is derived from *albo-* (white) and *rimosa* (cracked), in reference to the whitish limestone substratum being visible at the base of some cracks in the thallus.

Discussion: *Verrucaria alborimosa* is characterised by its very dark, subgelatinous, rimose-areolate and non-punctate thallus, small and inconspicuous perithecia with broadly clavate asci, comparatively long periphyses, a thin and predominantly hyaline excipulum and small, broadly ellipsoid ascospores. It is readily distinguished from its associate, the pantemperate *V. maura* which has a thicker, black-punctate thallus with a blackish hypothallus and larger perithecia, asci and ascospores (Orange et al. 2009; McCarthy 2012). The mainly Australasian *V. subdiscreta* is even more diminutive, but has a thallus that is commonly black-punctate, as well as smaller asci, shorter periphyses and narrower ascospores (McCarthy 2012).

In a significant re-evaluation of *Verrucaria* s. lat. based on molecular phylogenetic analysis and morphological considerations, Gueidan et al. (2009) resurrected and/or re-circumscribed old segregates and described new genera including *Hydroverrucaria* Keller, Gueidan & Thüs and *Wahlenbergiella* Gueidan & Thüs. These genera include intertidal and freshwater species, and they were segregated from *Verrucaria* based on molecular differences and the occurrence of pigmented dots and ridges on and/or within the thallus, and were distinguished from one-another by thalline anatomy and pigmentation and ascospore dimensions. However, we prefer to retain all Australian species (intertidal as well and terrestrial, freshwater and lichenicolous) in a broadly circumscribed *Verrucaria* (McCarthy 2012), at

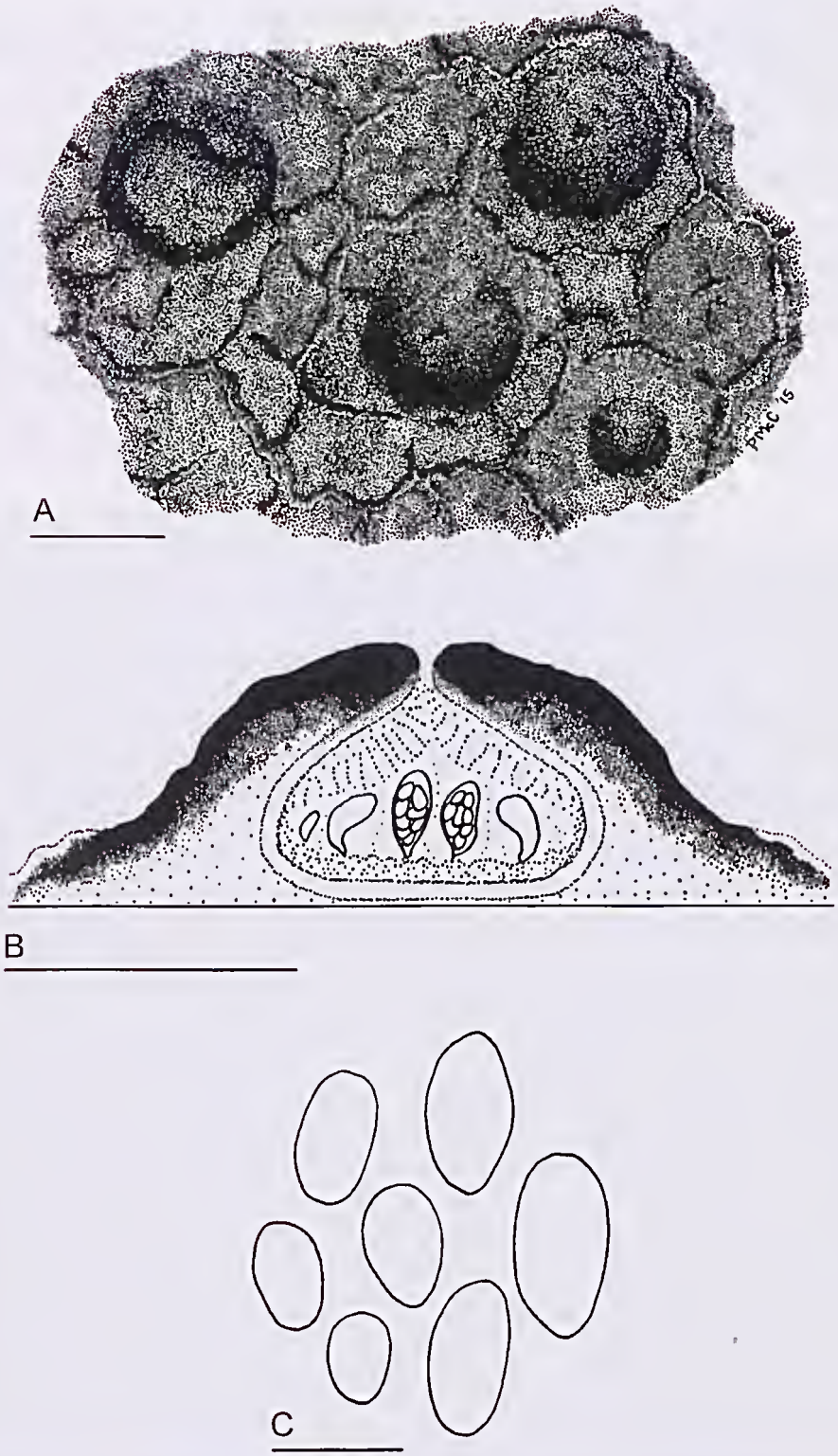

Figure 1. *Verrucaria alborimosa* (holotype): A. habit of thallus and perithecia; B. vertical section of perithecium (semi-schematic); C. ascospores. Scale bars: A = 0.2 mm; B = 0.1 mm; C = 10 µm

least pending a comparable assessment incorporating the numerous Australian and Australasian endemics, among them the punctate/ridged, intertidal species *V. corallensis* P.M.McCarthy and *V. subdiscreta* P.M.McCarthy.

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Key to *Verrucaria* on rocky seashores in Australia

1 Thallus endolithic or epilithic and inconspicuous (often visible only around perithecia), pale grey-green or pale pinkish grey; supralittoral species 2

1: Thallus epilithic and conspicuous, grey-brown to greenish brown, medium green, olive-green, green-black or black; littoral or supralittoral species 3

2 Perithecia 0.1–0.2 mm diam., semi-immersed to ±completely immersed; involucrellum absent; growing on limestone ..... ***V. australiensis***

2: Perithecia 0.4–0.7 mm diam., semi-immersed to almost superficial; involucrellum thick and well-developed; growing on siliceous rocks ..... ***V. praminula***

3 Thallus continuous to sparingly rimose; lower littoral to mid-littoral species 4

3: Thallus richly and deeply rimose to areolate; upper littoral to supralittoral species 8

4 Ascospores 10–20 µm long 5

4: Ascospores 6–13 µm long 6

5 Thallus with sparse to abundant black dots and ridges (especially distinct when the thallus is wetted); ascospores 13–20 × 3.5–5.0 µm; NE Queensland ..... ***V. carallensis***

5: Thallus lacking black dots and ridges; ascospores 10–16(–18) × 3.5–6.0(–8.0) µm; SE Australia ..... ***V. micrasparoides***

6 Thallus with elongate, simple or branched, carbonaceous ridges; perithecia frequently becoming excavate and irregularly uneven at maturity ..... ***V. striatula***

6: Thallus lacking carbonaceous ridges; perithecia remaining hemispherical at maturity 7

7 Perithecia 0.2–0.3 mm diam.; involucrellum 30–40 µm thick; ascospores 4.5–6.5 µm wide ..... ***V. halizaa***

7: Perithecia 0.25–0.45 mm diam.; involucrellum 70–100 µm thick; ascospores 5.5–10.5 µm wide ..... ***V. meridianalis***

8 Ascospores 8–16(–18) µm long 9

8: Ascospores 12–26 µm long 11

9 Perithecia 0.2–0.45 mm diam.; thallus pale grey-brown to medium greenish brown ..... ***V. aucklandica***

9: Perithecia 0.1–0.3 mm diam.; thallus dark olive-green to greenish black 10

10 Ascospores 4.0–6.5 µm wide; asci 25–35 × 10–14 µm; perithecia 0.1–0.2 mm diam ..... ***V. subdiscreta***

10: Ascospores 7–10 µm wide; asci 35–40 × 14–20 µm; perithecia 0.15–0.3 mm diam ..... ***V. alborimosa***

11 Thallus medium greenish grey to dark grey-brown; perithecia semi-immersed to almost superficial ..... ***V. fusconigrescens***

11: Thallus dark grey-green to greenish black; perithecia ±completely immersed in the thallus to semi-immersed; if prominent, then partly or almost completely overgrown by a thick layer of thallus ..... ***V. maura***

Muelleria

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ROYAL BOTANIC GARDENS VICTORIA

Isolation and characterisation of microsatellite markers for the dwarf sheoak *Allocasuarina humilis* (Casuarinaceae), an important understorey species in ecological restoration

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Introduction

The dwarf sheoak *Allocasuarina humilis* (Otto & A.Dietr.) L.A.S.Johnson (Casuarinaceae) is a dioecious wind-pollinated woody shrub endemic to the biodiverse Southwest Australian Floristic Region (SWAFR) of Western Australia. It occurs throughout most of the SWAFR, where it is found in vegetation communities ranging from heath to forest (Western Australian Herbarium 1998–). Plants grow to 2 m high, resprout from a lignotuber following fire and are thought to be very long-lived. Plants are diploid ($2n = 20$; Barlow 1959), flower from May to November (Western Australian Herbarium 1998–) and infructescences contain multiple glabrous samaras 5-6 mm long with a short truncate wing (Wilson and Johnson 1989) that may facilitate some wind dispersal. Seed dispersal via emus has also been noted (Calviño-Cancela et al. 2006).

Abstract

Eight polymorphic microsatellite markers were developed for *Allocasuarina humilis* (Otto & A.Dietr.) L.A.S.Johnson, a common woody shrub endemic to south-west Australia that is a common component of the understorey across a range of vegetation types. The markers were isolated using 454 shotgun sequencing and tested on 48 individuals from two natural populations. We found six to 19 alleles per locus (mean 12.1) and observed heterozygosity ranged from 0.208 to 0.956 (mean 0.710). The markers will be used to assess population structure and diversity in *A. humilis*, with the aim of developing appropriate seed sourcing strategies for ecological restoration.

Key words: *Allocasuarina*; microsatellites; SSRs

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Allocasuarina humilis is a common understorey component of ecological restoration programs for areas disturbed by logging, mining and roadworks and is also used in community-based restoration projects. Seed sourcing has been mostly conducted in areas local to restoration sites, following the principles of local provenance and the guidelines of the previous Western Australian Forest Management Plan (Conservation Commission of Western Australia 2004). However, with a fully outcrossing breeding system and the potentially widespread dispersal of pollen via wind, local sourcing of seed may not be the most appropriate strategy for *A. humilis*.

Molecular analysis can reveal patterns of gene flow, genetic diversity and population connectivity to better inform the seed sourcing decision-making process. Restoration outcomes are greatly improved when information on a species' genetic characteristics is incorporated into the planning phase of restorations (Godefroid et al. 2011). Here, we developed eight high resolution microsatellite markers for *A. humilis* with which to evaluate its genetic diversity and population structure, to assist in developing appropriate seed sourcing strategies for ecological restoration.

Materials and methods

Genomic DNA was extracted from freeze-dried leaf material from one *A. humilis* plant using the Doyle and Doyle (1987) CTAB method with 1% w/v polyvinylpyrrolidone (MW 40000) added to the extraction buffer. Shot-gun sequencing was conducted at the Australian Genomic Research Facility (Brisbane, Australia) using 4 µg DNA on a GS-FLX Titanium machine (Roche, 454 Life Sciences) following Gardner et al. (2011). We used QDD 1.3 (Meglécz et al. 2010) with default parameters to screen raw sequences for ≥ eight di- to hexa-base repeats. Primers were designed using Primer3 within QDD. Of the 539 unique loci, 10 were chosen for polymerase chain reaction (PCR) trials following recommendations in Meglécz et al. (2010) and Gardner et al. (2011). Loci were preferred that had pure microsatellite motifs ≥8 repeats in length that were >20 bp from primers.

Universal M13 tails (5'- CACGACGTTGTAAAACGAC) were appended to each forward primer at the 5' end, and the complement sequence was modified with a 5' fluorescent label (FAM, VIC, NED or PET). Singleplex polymerase chain reaction (PCR) amplifications were performed in an 8 µL reaction mix containing 20 ng template DNA (extracted from freeze-dried leaf material using the method detailed above), 50 mM KCl, 20 mM Tris-HCl (pH 8.4), 0.2 mM of each dNTP, 2.0–2.75 mM $MgCl_2$, 0.15 µM fluorescent labelled M13 primer, 0.03 µM forward primer, 0.15 µM reverse primer, 0.05 µL *Taq* DNA polymerase. Most reactions benefited from addition of 0.5 M betaine to the PCR mix (Table 1). Loci were amplified using one of two programs in an Eppendorf gradient thermocycler: (1) 95°C for 4 min; 15 cycles of 30 s at 94°C, 30 s at 65 to 50°C with a stepdown of 1 °C per cycle, and 72°C for 45 s; 30 cycles of 15 s at 94°C, 15 s at 50°C, and 45 s at 72°C; 8 min at 72°C; (2) as for Program 1, but the initial amplification step involved 25 cycles with a stepdown of 0.6°C per cycle and an extension phase of 80 s at 72°C. Products were visualised on 8% polyacrylamide gels stained with ethidium bromide, and PCR reactions were further optimised for $MgCl_2$ and/or betaine (as per Table 1). PCR products were visualised on an Applied Biosystems 3730 capillary sequencer and scored manually using GeneMapper 4.0 (Applied Biosystems).

Of the 10 loci screened, one did not amplify a product and one was monomorphic. The remaining eight loci were used to genotype and assess genetic diversity in 48 individuals from two natural populations (Table 1). The Donnybrook population is situated in open Jarrah forest 170 km south of Perth, while Lesueur is 210 km north of Perth in Kwongan heath. Both populations contained several hundred plants. Linkage disequilibrium among pairs of loci and deviations from Hardy-Weinberg equilibrium (HWE) were assessed using exact tests in Genepop 4.2 (Rousset 2008), applying the Bonferroni correction. Null allele frequencies were estimated for each locus using INEst 1.1 (Chybicki and Burczyk 2009) and genetic diversity parameters were estimated with Genepop 4.2.

Results and discussion

Evidence for null alleles and deviations from HWE was found for Ahum8 in both populations and for Ahum15 at Mt Lesueur (Table 1). As no deviations from HWE were found at other loci and the species is dioecious, the observed deviations were most likely caused by null

Table 1. Primer sequences and characteristics of ten microsatellite loci isolated from *Allocasuarina humilis*. See main text for details of PCR programs. Allele size range and number of alleles (N_A) are based on 48 individuals from two natural populations. Observed and expected heterozygosity (H_o, H_e) and null allele frequencies are based on 24 individuals within each natural population. One locus was monomorphic and one did not amplify.

Locus	Primer sequence (5′-3′)a	GenBank accession	Repeat motif	$MgCl_2$ (mM)	PCR progr	Size range (bp)	N_A	Donnybrook (n = 24) (33° 34′ 38.3″ S, 115° 51′ 9.2″ E)			Mt. Lesueur (n = 24) (30° 04′ 03.3″ S, 115° 07′ 40.5″ E)		
								H_o	H_e	Null allele	H_o	H_e	Null allele
Ahum6	F: TAAGCACGCAAAGAAACGCT	KM374578	$(AT)_9$	2.5	2[b]	104-128	10	0.826	0.820	0.034	0.500	0.705	0.105
	R: GGTCTTCATATTCAATCTCTTGGG												
Ahum8	F: CCACTGTTATGGCCTACAGGA	KM374579	$(AG)_{11}$	2.5	1[b]	94-122	12	0.522*	0.853	0.141*	0.542*	0.893	0.144*
	R: ACACAGTCAAGACGGCTTTC												
Ahum9	F: TGATGAATGTAATGAAGGCTGC	KM374580	$(GA)_9$	2.5	1	97-131	14	0.500	0.553	0.044	0.792	0.650	0.024
	R: TGGATTTAAGCTACCTGATGGA												
Ahum15	F: CCAACCAATCTACAGAACAGCA	KM374581	$(AT)_{10}$	2.5	1[b]	186-236	17	0.591	0.827	0.096	0.208*	0.920	0.272*
	R: TCTAACGTTCTGTCAAGCAATCA												
Ahum16	F: GCTGTCAGGTCTGGGTAAATTC	KM374582	$(CT)_9$	2.5	1[b]	159-191	12	0.833	0.789	0.028	0.875	0.815	0.025
	R: TGTACACGTTGGAGTTGTGGA												
Ahum18	F: AAGGAAATCACCCATAATCGAA	KM374583	$(ATT)_{20}$	2.25	1[b]	136-199	19	0.956	0.896	0.019	0.956	0.947	0.019
	R: AGCAAATTTGTCCAACACCC												
Ahum22	F: CAAGGCTTCAACCAAAGATCA	KM374584	$(AT)_8$	2.5	1[b]	129-141	6	0.667	0.768	0.064	0.667	0.576	0.043
	R: GCTGTACATGTTGGCAAGTCA												
Ahum24	F: TTTTGAGCGTATGCAATGGG	KM374585	$(GT)_{10}$	2.5	1[b]	110-122	7	0.783	0.808	0.042	0.583	0.662	0.076
	R: TCACCATTTAAATTGAGGGTCT												
Ahum11	F: TTTCTTTGCTTTGCTTTCTATGTTG	KT224416	$(AC)_8$	2.5	1[b]	90	0						
	R: ACGTCAATTGATCCAAAGAAA												
Ahum14	F: TCCCGGGATTGTAAGTGTTG	KT224417	$(TTCTGA)_9$	2.5	1[b]	191	1						
	R: TATCTCCTGCGAGACGTGTG												

a Forward primers include an M13 universal sequence appended to the 5′ end (5′- CACGACGTTGTAAAACGAC)

b 0.5M betaine included in PCR

* Significant deviation from Hardy-Weinberg equilibrium or significant estimate of null allele frequency ($P < 0.05$)

alleles rather than inbreeding. There was no evidence for linkage disequilibrium between any loci in either population. Among the 48 screened individuals, the number of alleles per locus ranged from six (Ahum22) to 19 (Ahum18), with a mean of 12.1. We detected moderate to high genetic diversity, with expected heterozygosity ranging from 0.553 to 0.947 (mean 0.789) and observed heterozygosity from 0.208 to 0.956 (mean 0.710).

These microsatellite markers are the first to be developed for a Western Australian *Allocasuarina* and have doubled the number of markers available for the genus. Reliable polymorphic microsatellites have proved difficult to isolate in *Allocasuarina* (Lamont 2010; Lamont et al. 2012; L. Broadhust pers. comm; this study). Six microsatellite markers have previously been developed for *A. verticillata* (Lam.) L.A.S.Johnson (Broadhurst 2011) and two for *A. emuina* L.A.S.Johnson (Lamont et al. 2012). Consistent with the relatively recent radiation of the genus (Steane et al. 2003), the markers developed by Broadhurst (2011) and Lamont et al. (2012) had high rates of transferability among *Allocasuarina* species both within and across sections (Lamont 2010). The eight microsatellite markers developed here for *A. humilis* are therefore expected to be transferable to other *Allocasuarina* species for which assessment of genetic characteristics may be required for conservation or other purposes. These markers are being used to evaluate the patterns of genetic diversity, divergence and structure among *A. humilis* populations in the SWAFR in order to inform appropriate seed sourcing strategies for restoration of disturbed or degraded land.

Acknowledgements

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Muelleria

34: 63-67

ROYAL
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A name for Murnong (*Microseris*: Asteraceae: Cichorioideae)

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Introduction

With the publication of the first Asteraceae volume of the Flora of Australia (Wilson 2015), we have a national perspective of the taxonomy of *Microseris* D.Don (Sneddon 2015). The Flora account provides descriptions and complete synonymies for the two species regarded as comprising the genus in Australia, *M. lanceolata* (Walp.) Sch.Bip. and *M. scapigera* Sch.Bip., whereas, in most jurisdictions, only one, *M. lanceolata*, had been recognised since the inclusion of *M. scapigera* as a synonym (e.g. Ross 1990; CHAH 2011).

Sneddon's treatment provides useful and detailed notes under both species, with those relating to *M. lanceolata* being quite extensive. For many years, MEL has recognised three distinct taxa (e.g. Ross 1993; Jeanes 1999, Walsh & Stajsic 2007) but one has remained as an informal taxon only (*Microseris* sp. 3 or *Microseris aff. lanceolata* (Foothills)). This has been unfortunate, particularly given that, of the three entities involved, the informally recognised one has long been acknowledged as one of the most important food plants of aboriginal people of south-eastern Australia and for which the Koorie name 'Murnong' (or 'Myrnong') has long been applied (e.g. Gott 1983) in Victoria, and 'Garngeg' or 'Nyamin' in south-eastern New South Wales (Blackburn *et al.* 2015). The characteristic root system of Murnong, producing a plump, annually replaced tuber, provides both the major food source and a critical taxonomic feature (Fig. 1a). The tubers are commonly described as sweet-tasting, both raw and cooked. Sneddon notes that the 'Murnong form' of *M. lanceolata* is a lowland, spring-flowering, summer-dormant entity whereas montane to alpine forms (concordant with the type of *M. lanceolata*) are summer-

Abstract

An existing name, *Microseris walteri* Gand., is resurrected for one of the most important food plants of aboriginal people of south-eastern Australia and for which the Koorie name 'Murnong' (or 'Myrnong') has long been applied (e.g. Gott 1983) in Victoria, and 'Garngeg' or 'Nyamin' in south-eastern New South Wales. It is compared with its two Australian congeners. A key to the identification of all three species and photographs of their root systems are provided.

Keywords: Aboriginal food plant, daisy, identification, Nyamin, Garngeg

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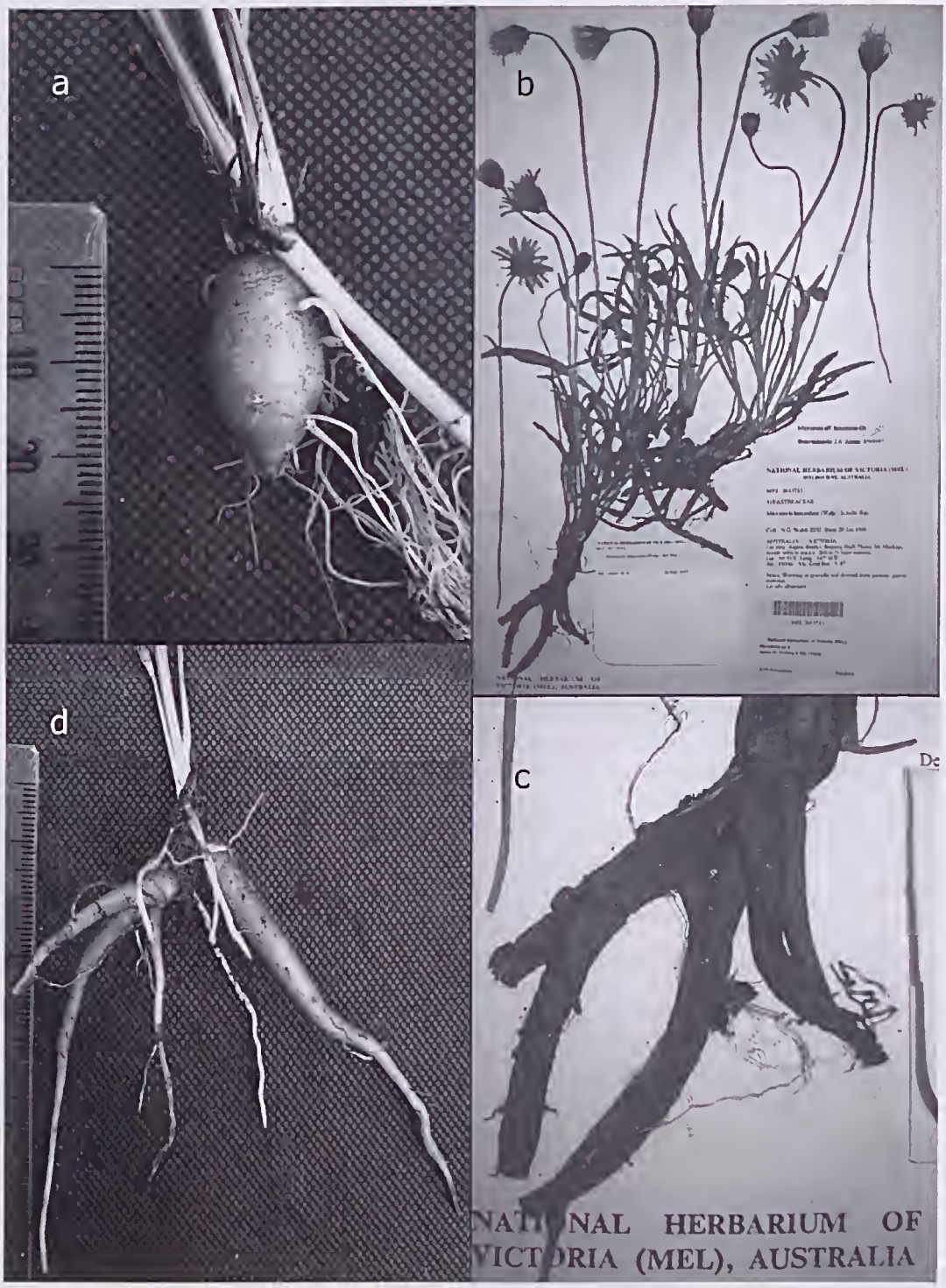

Figure 1. Root systems of Australian *Microseris*. 1a (top left). *M. wolteri*. The pale slender root to the right of the 'mother tuber' will expand to become the replacement tuber after the mother tuber has been exhausted following emergence of the new leaves in spring. (cultivated by the author); 1b (top right). *M. lonceoloto*. Branched, fleshy root system similar to that of *M. scopigero*. (*N.G.Wolsh 2252*, MEL 2013713); 1c (bottom right). Enlargement of 1b; 1d (bottom left). *M. scopigero*. Several fleshy roots branched just below ground-level. (cultivated by the author)

flowering and winter dormant. It is worth noting that within Murnong there is considerable variation in tuber shape—e.g. plants from north-western Victoria growing in deep sands produce elongated tubers to c. 8 cm long or more (pers. obs.) The root system of *M. lanceolata sens. str.* is fleshy but not tuberous, usually branched near the soil-level and comprises cylindrical or gradually tapering structures (Fig. 1 b,c). Its use as an aboriginal food plant is not reliably reported. I have eaten the roots, both raw and roasted, and found them bitter, slightly fibrous and not particularly palatable. The root system of *M. scapigera* (Fig. 1d) resembles that of *M. lanceolata*. It is not known if the roots of *M. scapigera* were eaten by aborigines, but they are fleshy, only slightly fibrous, and slightly, but tolerably bitter when eaten raw (pers. obs.).

Smyth (1876, p. 171) reported at Coranderrk Mission (Healesville, Victoria) that 'the natives' ate the roots of non-native *Hypochaeris glabra* L. ('Nareengnan' in the local language) which does not have tuberous roots. This is interesting as, today, *H. glabra* is not a particularly common plant in these parts (but *H. radicata* L. is), suggesting perhaps misidentification. However Smyth notes that the species listed were identified by Ferdinand Mueller, the Government Botanist at the time, and Mueller was certainly aware of *Microseris* (which he identified as a food plant elsewhere in Victoria in the same work) and *H. radicata*. It is possible that, recognising the similarity between *H. glabra* and *Microseris*, the Coranderrk aborigines adapted to the weed as it appeared in the district, suggesting further that they may have been accustomed to consuming non-tuberous species of *Microseris*. Both of these species occur within ca. 50 km of Healesville today, so it is very conceivable that they were known by the Coranderrk aborigines and were consumed by them. Often quoted, early reports of plains west of Melbourne carrying large populations of *Microseris* (e.g. Mitchell's 1839 reference to a 'cichoraceous plant') include comments about their importance as a food plant. Both *M. scapigera* and Murnong are now rare on these plains following extensive early grazing (Lloyd 1862; Clark 1998).

Sneddon's provision of synonymy, and in particular, his interpretation of Gandoger's taxa which were perfunctorily 'described' via a simple key only (Gandoger 1918), has allowed the association to be made between Murnong and one of Gandoger's names. Features of the pappus of Murnong as well as its presumed outbreeding mating system suggest it is closer to *M. lanceolata* than *M. scapigera*. Capitula of typical, montane to alpine *M. lanceolata* and Murnong remain open for a day or more and seed production may be variable, whereas those of *M. scapigera* (at least in Victoria) remain open for only an hour or two and have a high level of seed-set (pers. obs.), suggesting not only inbreeding, but cleistogamy.

After consulting original descriptions, type images and type specimens at MEL of the synonyms provided under *M. lanceolata* — viz *Scorzonera lawrencei* Hook.f., *M. forsteri* Hook.f., *M. latifolia* Gand., *M. forsteri* var. *subplumosa* Benth. and *M. walteri* Gand. — it became obvious that only the latter two represent a tuberous-rooted entity, and while *M. forsteri* var. *subplumosa* is the earlier name, *M. walteri* is the only name available for the taxon at species rank (Art. 11.2 ICN; McNeill et al. 2012) (Fig. 2). Further, *M. forsteri* itself is regarded as a synonym of *M. scapigera* and is based on a New Zealand type.

The following key to the Australian species of *Microseris* is essentially a replication of the key in Jeanes (1999) with further detail of root structure based on field observation, herbarium material and cultivated plants. I have grown plants of *M. scapigera* and *M. walteri* in identical media and conditions and they have replicated the root system of their parents. I haven't had the opportunity to grow *M. lanceolata*, but have examined

Key to Australian species of *Microseris*

1 Cypselas mostly 7–10 mm long; pappus scales 30–66 mm, hardly widened at base; ligules to c. 12 mm long; roots several, cylindrical or long-tapered, usually branched shortly below leaves; mostly from basalt plains of western Victoria and elevated sites in Tasmania ..... ***M. scapigera***

1: Cypselas usually less than 7 mm long; pappus scales to c. 20 mm, noticeably widened at base; ligules usually more than 15 mm long; roots cylindrical or napiform, branched or not; lowland to alpine plants, rarely on basaltic soils 2

2 Pappus scales 10–20 mm, c. 0.3–0.5 mm wide at base; fleshy roots several, cylindrical to long-tapered, branching just below ground-level; alpine and subalpine NSW, ACT and Victoria ..... ***M. lanceolata***

2: Pappus scales usually c. 10 mm, 0.5–1.3 mm wide at base; fleshy root expanding to a solitary, napiform to narrow-ellipsoid or narrow-ovoid, annually replaced tuber; lowlands of temperate southern WA, SA, NSW, ACT, Vic., Tas. ..... ***M. walteri***

Figure 2. Holotype of *M. walteri* Gand. (LY 9479, reproduced with permission). Note the spent 'mother tuber' and its replacement tuber on the middle specimen. Other specimens collected without below-ground parts.

numerous examples in the field and the mature root system of these appears uniform.

While based primarily on Victorian specimens, the key, based on herbarium specimens at MEL, appears to be applicable to Australia generally, notwithstanding Sneddon's note about a 'variant' from lowland sites in Tasmania that has unusually short (c. 3 mm long) pappus scales. While discussed under *M. lanceolata*, Sneddon notes this variant 'may be closer to *M. scapigera*'. It is clearly not part of what is here resurrected as *M. walteri*.

Taxonomy

Microseris walteri Gand., *Bull. Soc. Bot. France* 65:52 (1918) (as *Microderis walteri*)

T: Victoria, Sandringham, Sept. 1900, *C.Walter s.n.*; holo: LY (photo seen).

Microseris forsteri var. *subplumosa* Benth. Fl. Austral. 3:676 (1867). T: W. Australia, *J.Drummond 5th Coll., 366*; holo: K (photo seen); ?iso: MEL (2 sheets).

Microseris sp. 3 sens. J.A.Jeanes in N.G.Walsh & T.J.Entwisle (eds), *Flora of Victoria*, vol. 4, 702 (1999).

Microseris aff. *lanceolata* (Foothills) sens. J.H.Ross, *Census Vasc. Pl. Victoria*, edn 5, pp. 49, 185 (1996).

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Muelleria

34: 69-82

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Recognition of subspecies in *Asterolasia trymalioides* (Rutaceae: Rutoideae)

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Introduction

Asterolasia trymalioides F. Muell. was described in 1854 from material collected in the Cobberas Mountains in far eastern Victoria (Mueller 1854). Since then, the genus *Asterolasia* and *A. trymalioides* have been variously placed in *Eriostemon* Sm. (Mueller 1859) and *Pleurandropsis* Baill. (Anon. 1923).

Asterolasia trymalioides is a common component of some heathlands of treeless plains and peaks in the Australian Alps (McDougall & Walsh 2007) and has been the subject of ecological studies on shrub cycles and disturbance regimes (e.g. Williams & Ashton 1988). It is widely known as the Alpine Star-bush. However, the species has also been recorded well outside the Australian Alps Bioregion and in vegetation that is not alpine (Harden & Mole 2002). Wilson (2013) commented about a difference in leaf shape between Victorian and New South Wales (NSW) specimens but did not indicate whether these warranted taxonomic distinction, nor did he explore morphological differences between plants in the Australian Alps and those occurring elsewhere.

From our cursory examination of wild populations in the Australian Capital Territory (ACT), the Tinderry Range and Morton National Park in NSW, further taxonomic investigation was clearly warranted. Populations in the Tinderry Range and the ACT, at least, are visually distinctive

Abstract

Asterolosia trymalioides F.Muell. is revised. Analysis of morphological attributes supports the recognition of three taxa which are geographically separated. *Asterolosio trymolioides* subsp. *trymolioides* is a widespread shrub of alpine and subalpine heathlands in the Australian Alps; *A. trymolioides* subsp. *oreniticola* K.L.McDougall & C.J.Hook is confined to poorly-drained heaths of the Budawang Range of south-eastern New South Wales and *A. trymalioides* subsp. *villoso* K.L.McDougall & C.J.Hook is known from heathland of elevated rocky sites of the Australian Capital Territory and the Tinderry Range of south-eastern New South Wales, with an outlier in far eastern Victoria. A population in the Thredbo valley may be a hybrid of subsp. *trymolioides* and subsp. *villoso*.

Keywords: Rutaceae, *Asterolosio*, taxonomy, Budawangs, Namadgi

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with a dense indumentum on apical branchlets and leaves. Populations in Morton National Park are much taller than those we have seen elsewhere, occur in very different habitat and are geographically isolated. In this paper we evaluate differences between geographically isolated populations to assess whether the superficial differences we observed warrant taxonomic recognition.

Materials and Methods

All collections of *Asterolasia trymalioides* at MEL, CANB and NSW were examined. Places with few collections (the Tinderry Range near Michelago, Thredbo River in Kosciuszko National Park and Morton National Park in NSW, and Bowen Range in eastern Victoria) were searched and additional material obtained where possible. All but the Bowen Range population were relocated and new populations were located along the Thredbo River and in Morton National Park.

Measurements were made from dried material of the following characters where present.

1) *Hairs on stems and leaves.* The hairs of *A. trymalioides* are stellate and may be sessile or stalked. Stalked hairs, where present, are found amongst a dense indumentum of sessile hairs. The rays of the stellate hairs (collectively forming what are here termed the *stellae*) are typically shed with age, leaving upper leaf surfaces and old stems glabrescent, or at times somewhat hispid with the persistent stalks. Measurements were made on young stems where hairs were still plentiful. Measurements of maximum stalk length and stella width were made from three hairs on each collection and averaged.
2) *Leaf dimensions.* The leaves of *A. trymalioides* vary in size and shape on individual plants, usually depending on distance from the growing tip (i.e. maturity). Floral leaves are relatively small and overlapping. Measurements were made from isolated leaves on the primary stems of collections. Three measurements of petiole, leaf length (including petiole) and width, and the width of the leaf abaxial surface obscured ('obscuration') by the recurved margins were made for each collection and averaged. Leaf shape was characterised as the ratio of the leaf lamina to leaf width.
3) *Floral characters.* Three measurements were made on each flowering collection of petal length, staminal filament length, anther length, style length, and stigma width (when fully expanded) and averaged.

Very few collections contained fruiting material. Measurements of seeds and follicles were used in taxonomic descriptions but not morphometric analysis.

Data analysis

Of the collections examined, 48 were fertile and all characters could be included in analyses performed using Primer v.6 (Clarke & Gorley 2006). Three characters (stella width, leaf shape and petal width) were removed because they were highly correlated with related characters. The data were first normalised – the mean was subtracted from each value and divided by the standard deviation – to account for differences in the magnitude of measurements between variables and a matrix of similarities created using a Euclidean distance metric. Relationships between collections of *Asterolasia* were investigated using the routine CLUSTER (hierarchical agglomerative clustering). Structure in the dendrogram produced by CLUSTER was tested using the routine SIMPROF with a significance level of 5%. Infertile collections and those falling somewhat intermediately between groups in CLUSTER were assigned to groups where possible using CAP (canonical analysis of principal components) in Permanova+ (an add-in to Primer v6) on normalised leaf and indumentum characters only.

Results

Morphometric analysis

Three groups of collections were supported by the CLUSTER analysis (Fig. 1) - Group 1: ACT and Tinderrys, Group 2: Morton National Park and Thredbo and Group 3: the rest of the Australian Alps. Maximum hair stalk length and stella width, petiole length, leaf width, petal length and width, stigma width, anther and style length are likely to have diagnostic value because there is little or no overlap in these characters for two or all groups (Table 1). The CAP analysis allocated all of the infertile collections from the ACT (Mt Scabby, Mt Kelly, Sentry Box Hill and Mt Gudgenby) and the single collection from the Tinderry Range in NSW to Group 1. It also

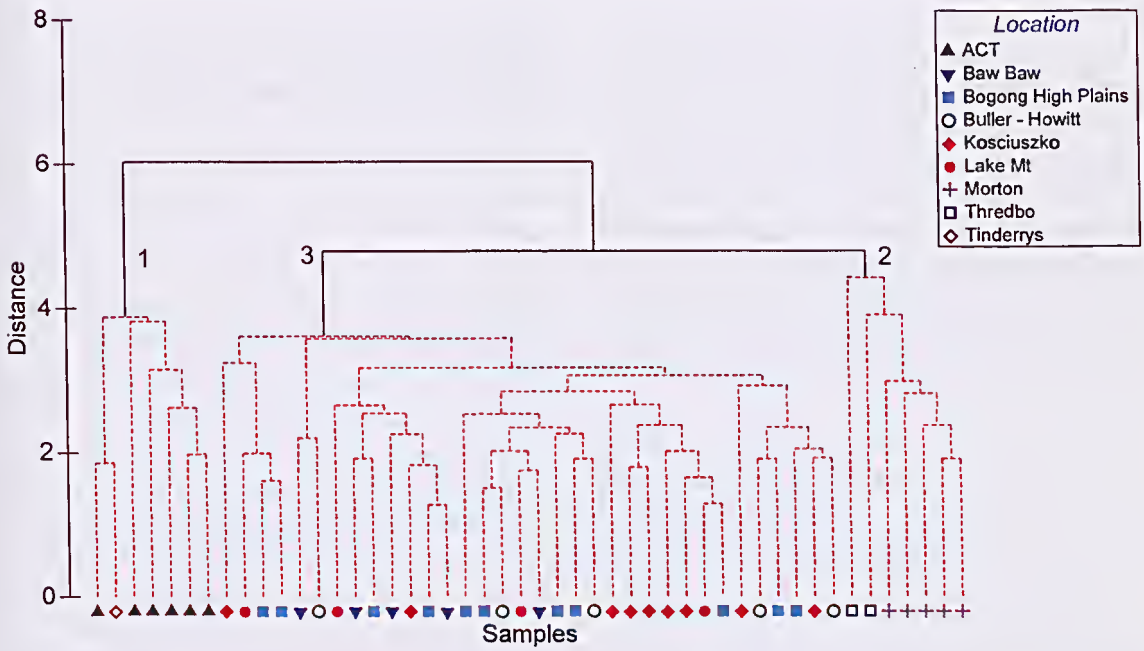

Figure 1. Dendrogram of fertile herbarium collections of *Asterolasia trymalioides* generated using the CLUSTER routine of Primer v.6. The solid lines indicate the groups supported at the 5% significance level using SIMPROF (in Primer v.6). The group numbers are those referred to in the text.

Table 1. Morphometric characters (mean ± SE) for the three groups identified in the CLUSTER analysis. A superscript number indicates that there was no overlap between the 5 and 95 percentiles of measurements for those groups (e.g. for anther length there was no overlap in measurements between Groups 1 and 2 but Group 3 collections overlapped with both Groups 1 and 2). Measurements for the two intermediate collections from Thredbo are shown – the number(s) in parentheses indicate the Group(s) within which the measurements fall.

Morphometric character	Group 1	Group 2	Group 3	Thredbo collections (groups)
Maximum stalk length (mm)	1.0 ± 0.1[2,3]	0.3 ± 0.0[1]	0.1 ± 0.0[1]	0.7–1.3 (1)
Maximum stella width (mm)	1.2 ± 0.1[2,3]	0.5 ± 0.0[1]	0.5 ± 0.0[1]	0.6–0.7 (2,3)
Leaf length (mm)	8.8 ± 0.4	7.2 ± 0.2	6.9 ± 0.2	6.2–6.3 (3)
Leaf width (mm)	4.3 ± 0.2[2]	3.6 ± 0.2	2.5 ± 0.1[1]	2.7–3.1 (3)
Leaf shape (lamina length:width)	1.4 ± 0.1	1.5 ± 0.0	2.2 ± 0.1	1.5–1.7 (1,2,3)
Obscuration (mm)	0.5 ± 0.1	0.4 ± 0.0	0.5 ± 0.0	0.5–0.8 (1,3)
Petiole length (mm)	2.7 ± 0.1[2,3]	1.6 ± 0.2[1]	1.5 ± 0.1[1]	1.5–1.7 (2,3)
Petal length (mm)	8.9 ± 0.5[3]	8.2 ± 0.3[3]	5.2 ± 0.1[1,2]	6.5–7.0 (1,2)
Petal width (mm)	4.4 ± 0.2[3]	4.4 ± 0.3[3]	2.5 ± 0.1[1,2]	2.6–3.5 (2,3)
Staminal filament length (mm)	4.8 ± 0.2	4.9 ± 0.4	4.5 ± 0.1	4.5–5.5 (1,2,3)
Anther length (mm)	1.6 ± 0.1[2]	1.2 ± 0.1[1]	1.4 ± 0.0	1.0–1.5 (1,2,3)
Stigma width (mm)	1.2 ± 0.1[3]	0.7 ± 0.0[3]	1.8 ± 0.1[1,2]	1.0–1.2 (1)
Style length (mm)	5.5 ± 0.5[3]	4.3 ± 0.2	2.5 ± 0.1[1]	3.7–6.0 (1,2,3)

allocated one of five collections from Thredbo and the single collection from Mt Bowen to Group 1. The remainder of the infertile collections were assigned to Groups 2 or 3 but since there is little diagnostic value in hair and leaf characters between Groups 2 and 3, the assignment of collections by CAP to these groups is not informative. The infertile ACT and Tinderry collections are consistent geographically with the identification of this group based on floral, hair and leaf characters. Mt Bowen, however, is in East Gippsland, 140 km from the nearest definite collection from Group 1 and Thredbo is situated between Mt Bowen and the ACT (Fig. 2).

There is strong support from the CLUSTER analysis for the taxonomic separation of plants of the southern ACT, Booroomba Rocks and Tinderrys (Group 1), Morton National Park (Group 2) and the remainder of the Australian Alps (Group 3). Based on infertile material, a disjunct collection from Mt Bowen in East Gippsland is likely to be part of Group 1. Plants from the Thredbo area are morphologically intermediate. Although the

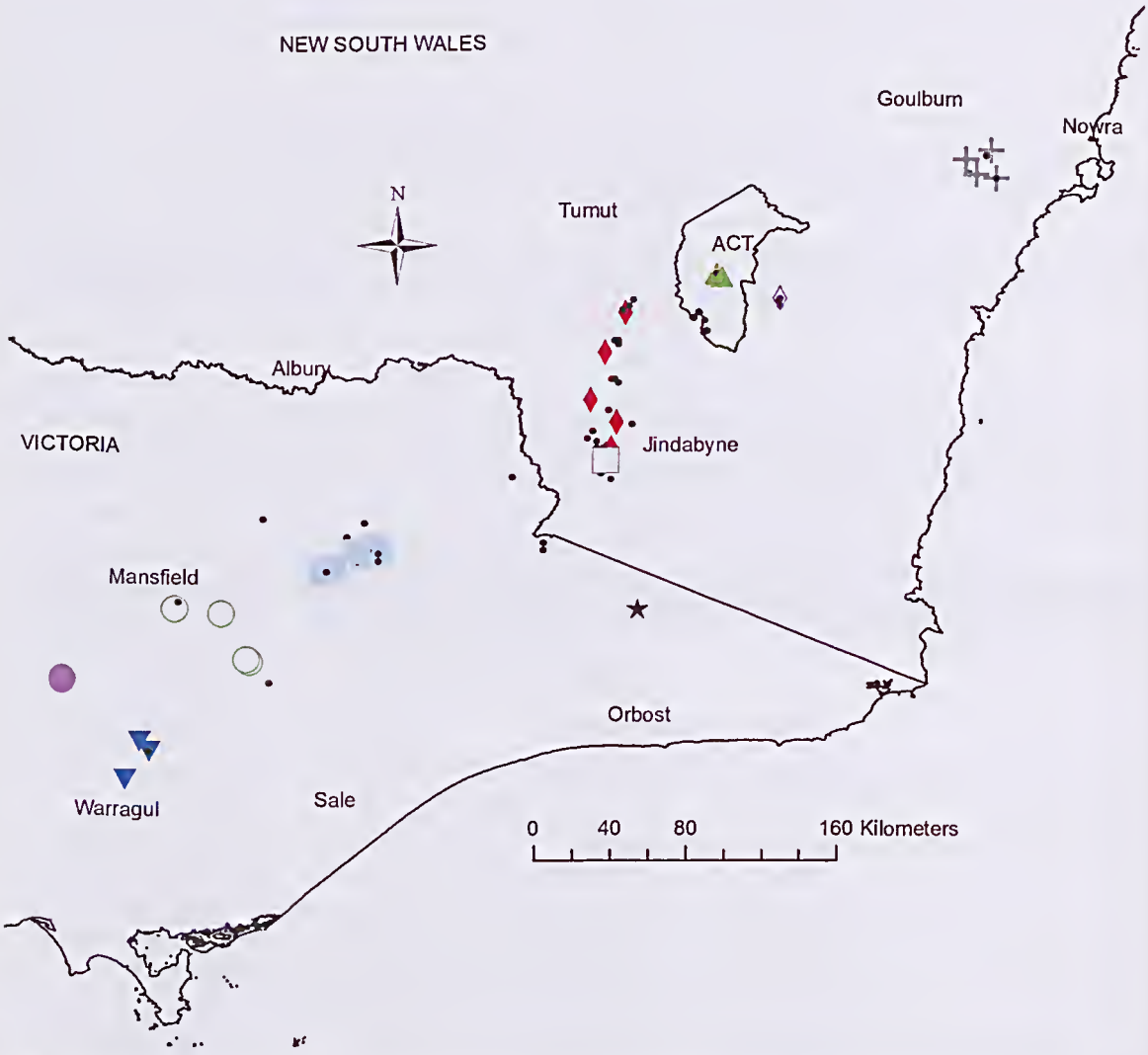

Figure 2. Distribution of collections from the nine broad locations delineated in Fig. 1. The symbols are the same as those used in Fig. 1 except for small dots, which are infertile collections not included in the CLUSTER analysis and the star, which is the Mt Bowen site assigned to Group 1 collections in the CAP analysis.

CLUSTER analysis placed them in Group 2 (Morton National Park), the CAP analysis placed most collections into the other groups. Given their proximity to Group 3 and their occurrence mid-way between Mt Bowen and the ACT, we suspect that they represent hybrids between Groups 1 and 3.

Discussion

We conclude that the current concept of *Asterolasia trymalioides* contains three taxa: one, which occurs in the Australian Alps from Lake Mountain and Baw Baw in Victoria to the Kiandra area of NSW (Group 3); one in Morton National Park, N5W (Group 2); and one in the mountains of the ACT and the Tinderry Range in N5W, with an outlier in the Bowen Range in eastern Victoria (Group 1). Group 3 contains the Type population in the Cobberas Mountains of north-eastern Victoria. We assign the names subsp. *villosa* to Group 1 plants and subsp. *areniticola* to Group 2 plants. We choose to designate these taxa as subspecies of *A. trymalioides*, given their similarity to other members of that species and substantial morphological differences from most other *Asterolasia* species (e.g. in pedicel length, flower colour, flower arrangement, leaf size, petiole length etc.). The Thredbo population (at an altitude of about 1150 m) is somewhat intermediate between all subspecies but most plants have the characteristic villous indumentum found in subsp. *villosa*. We suspect it is a hybrid between subsp. *villosa* and subsp. *trymalioides*, the nearest population of which is only 7 km away (although 500 m higher in altitude).

Taxonomy

Asterolasia trymalioides F.Muell., *Trans. Philos. Soc. Victoria* 1: 10 (1854)

Eriostemon trymalioides (F.Muell.) F.Muell., *Fragm.* 1(5): 106 (1859); *Pleurandropsis trymalioides* (F.Muell.) Anon., in Anon. (1923); Census Pl. Victoria, edn 1: 40.

Type citation: 'On the rocky summit of the Cobboras (sic) mountains in the Australian Alps, at an elevation of more than 6,000 feet above the level of the sea' (lectotype (here chosen): 'In [?]vertice montis Cobra locis graminosus lapidosus, ii.1854, *F. Mueller s.n.* MEL 708610!; possible isolectotypes: K 717302 (photo seen); MEL 106337!, 708609!; TCD 13339 (photo seen).

Nearly prostrate to erect *shrubs* to 2 m high; *branchlets* at least initially densely covered with pale to rusty stalked stellate hairs, older stems glabrescent. *Leaves* ovate to obovate or orbicular, petiolate, thick-textured, apex rounded or obtuse, margins revolute; upper surface initially stellate-pubescent, but finally glabrous, sometimes tuberculate; lower surface densely stellate-tomentose, with hairs like those of branchlets. *Flowers* terminal, solitary, closely subtended by several reduced floral leaves, sessile; *sepals* oblong, obovate or elliptic, minute, membranous, externally stellate-pilose; *petals* elliptic to obovate, yellow, stellate-tomentose outside; *stamens* 10, alternating long and short; ovary densely stellate-tomentose; *style* simple, occasionally with sparse stellate hairs, *stigma* ± hemispherical, 5-lobed, the lobes tuberculate and recurved. *Follicles* tomentose, ±cuneate, not beaked, c. 4 mm long. *Seed* ±reniform, c. 3 mm long, 1.5 mm wide, dark brown; aril elliptic, c. 2 mm long, 1.5 mm wide, membranous, closely adherent to the adaxial angle of the seed and soon deciduous.

Notes: Of the specimens of *A. trymalioides* from the Cobberas Mountain, the only one that includes the collecting date of February 1854 and the label (written by Mueller in Latin) that more or less matches the type citation had been annotated as the holotype (Paul G. Wilson *in sched.*). Four other sheets collected by Mueller from the Cobberas area were located in this study. Mueller is known only to have visited this area on two occasions (February and December 1854; Willis & Cohn 1993), so the undated specimens may or may not be part of the type collection. They are all in approximately the same stage of flowering/fruiting. To avoid any confusion, we have lectotypified the name on the dated Mueller specimen with the original handwritten label in Latin and treat the others as possible isolectotypes.

The synonym *Pleurandropsis trymalioides* was first published, as a *comb. nov.* in the 'Census of the plants of Victoria ...' (Anon. 1923). The authorship of this publication is obscure, being a census of names accepted by the 'Plants Names Committee' of the Field Naturalists Club of Victoria. In this publication, *Asterolasia* is maintained as a distinct genus, but containing only *A. muelleri* Benth., *nom. illeg.* (=*A. asteriscophora* (F.Muell.) Druce). Ewart (1930) maintained this distinction and nomenclature. Indeed, Ewart was likely to have been an influential member of the 'Plant Names Committee',

Key to subspecies

1 Leaves, stems and especially, new growth densely covered in stalked, stellate hairs with stalks up to 1.7 mm long and stellae up to 1.5 mm diam., the stalks persisting as sparse to moderately dense tubercles or short bristles; mountains of the ACT, the Tinderry Range in NSW, and Bowen Range in Victoria ..... 3. ***A. trymolioides*** subsp. ***villoso***

1: Leaves and stems variously hairy when young but stalks of stellate hairs, when retained, mostly < 0.5 mm long (very rarely to 0.9 mm) and stellae 0.3–0.9 mm diam., adaxial surface of leaves soon glabrous, but with scattered tubercles; Australian Alps in NSW and Victoria, and Morton National Park in NSW 2

2 Petals bright yellow and typically 7.5–10 mm long, leaf margins recurved but margins usually covering up to 10% of the abaxial surface; style mostly >3 mm long, stigma to 0.8 mm diam. when fully expanded; erect shrub to 2 m tall growing on sandstone in Morton National Park, NSW ..... 2. ***A. trymolioides*** subsp. ***areniticolo***

2: Petals dull yellow and typically 5–6 mm long, leaf margins recurved with margins covering c. 20% or more of the abaxial surface; style mostly <3 mm long, stigma > 1.3 mm diam.; prostrate or low shrub of the Australian Alps in Victoria and NSW ..... 1. ***A. trymolioides*** subsp. ***trymolioides***

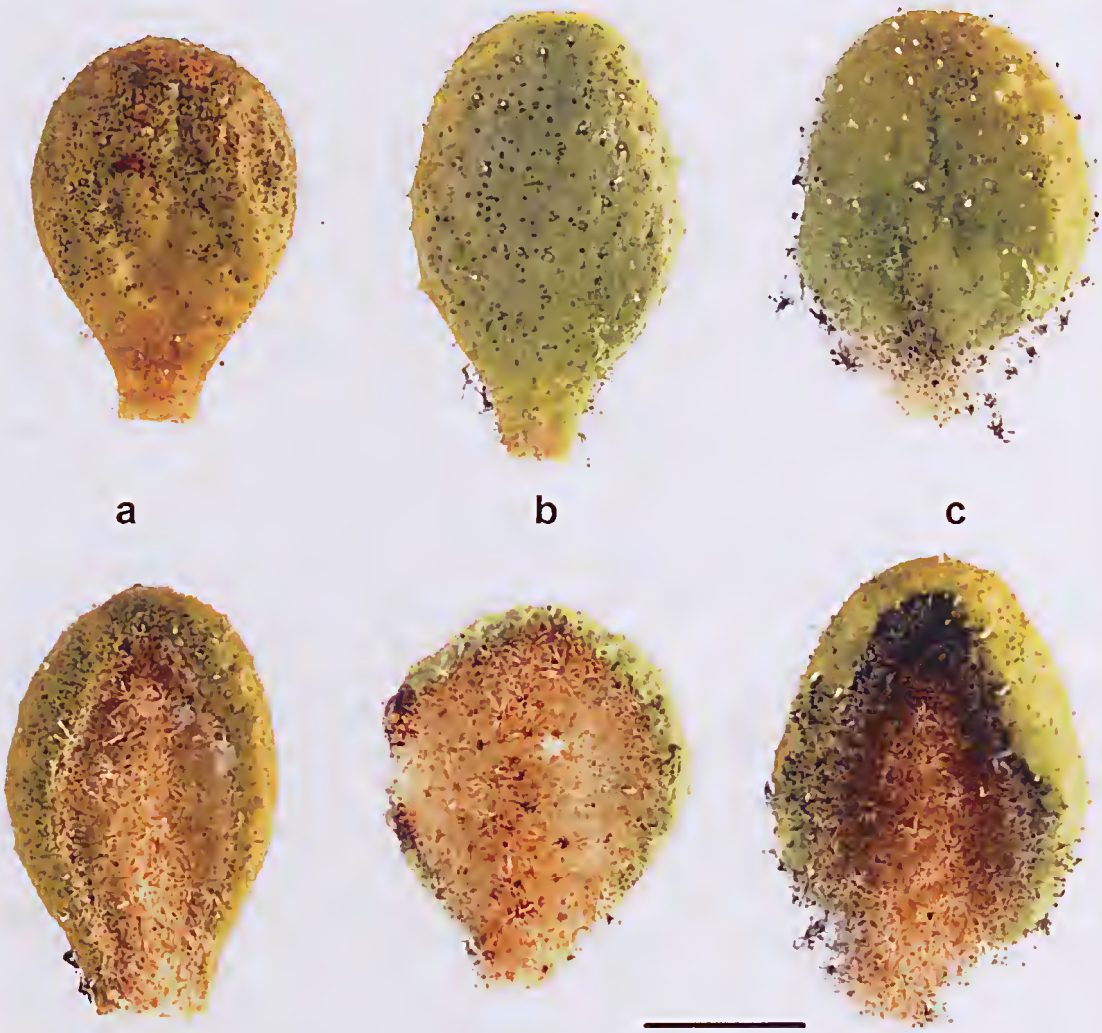

Figure 3. *Asterolasia trymalioides* leaves, upper and lower surfaces. **a.** subsp. *trymalioides*; **b.** subsp. *areniticola*; **c.** subsp. *villosa* (note the remnants of stalked hairs apparent near recurved margin of adaxial surface). Scale bar = 2 mm. (**a**: J.A.Jeanes 1930 (MEL); **b**: N.G.Walsh 8186 (MEL, holotype); **c**: N.G.Walsh 8102 (MEL)

being actively involved with club members in this period (Cohn 2005), but there is no attribution to him in the *Census*. Hence, authorship of *P. trymalioides* is correctly '(F.Muell.) Anon.' rather than '(F.Muell.) Ewart' as given in e.g. Wilson (2013).

Wilson (2013) described the sepals of *Asterolasia* as 'small, minute or absent' and those of *A. trymalioides* to be unusual in that they 'vary greatly in size on the same flower'. Of *A. phebalioides* F.Muell., the species he regarded as most closely related to *A. trymalioides*, he noted 'The 5 leafy to scarious bracts that subtend the flower occur in an inter-petaline position and may represent sepals'. After examining numerous flowers in the course of this study, both fresh and dried, it appears that the 'sepals' of *A. trymalioides* are similarly ambiguous; that is, the measured structures in the descriptions are as likely to be bracts as they are to be true sepals. Unlike most other members of the genus where the flowers are held clear of subtending leaves by distinct pedicels so that sepals, when present, are readily detected, these two species have essentially sessile flowers subtended by a series of decreasingly leaf-like bracts culminating in structures that resemble sepals. The varying lengths of these structures, even within individual flowers, suggests that they are not truly sepals, and like some other members of the genus, the flowers might be best described as lacking sepals.

Asterolasia phebalioides F.Muell., a rare shrub from Kangaroo Island and western Victoria, is perhaps closest in morphology to *A. trymalioides* but differs *inter alia* in having sessile, flat leaves and persistent adaxial leaf hairs.

1. *Asterolasia trymalioides* subsp. *trymalioides*

Low spreading shrub to 50 (rarely to 80) cm high, often ±prostrate; *hairs of leaves and branchlets* with stellae 0.3–0.6(–0.9) mm diam. and stalks to 0.3(–0.9) mm long; older stems often retaining remnants of hair-stalks. *Leaves* narrowly to broadly elliptic or obovate, (4.3–)5.6–8.1(–10.0) mm long (including petiole (0.4–)1.0–1.8(–2.7) mm), 1.7–2.9(–3.8) mm wide, apex rounded or obtuse, the recurved margins generally obscuring (11–)17–27 (–34)% of the lower surface; upper surface initially stellate-pubescent, but finally shiny and glabrous or

Figure 4. *Asterolasia trymalioides* subsp. *trymalioides*, flowering plant, Baw Baw plateau, Victoria (photograph I. Dunn, ©Royal Botanic Gardens Victoria)

sometimes weakly tuberculate. *Sepals* 1–2 mm long; *petals* (3.5–)4.9–5.8(–7.5) mm long, 2.0–3.0 mm wide, dull yellow; *staminal filaments* 3.1–5.2–(8.5) mm long; *anthers* 1–2 mm long; *style* 1.3–3.0(–4.5) mm long; *stigma* (1.3–)1.5–2(–2.8) mm diam. when fully expanded. Flowering: typically November–December but to late January in higher elevations in Victoria (Figs. 3, 4).

Selected specimens (of 58) examined: **NEW SOUTH WALES.** 1 km S of Daners Gap, Kosciusko area, 14.xii.1983, M. Gray 7057 & C. Totterdell (CANB); Burrumgubugee Hut, Kosciuszko National Park, 23.xi.2009, K.L. McDougall 1338 (CANB); 24 km NW of Jindabyne on the Geehi Reservoir road from Guthega power station, 20.iii.1984, R.G. Coveny 5400 (NSW); Happy Jack's Plains, Snowy Mtns, at creek crossing below hut, 19.xii.1967, E.M. Canning 443 & M.E. Phillips (CBG); Grey Mare Ridge, between Grey Hill and The Grey Mare, 27.xii.1968, A.N. Rodd 701 (NSW); western slopes of Mt Jagungal, Kosciuszko National Park, eastern side of Grey Mare Fire Trail, 9.xii.2009, K.L. McDougall 1347 (CANB); 7 km N of Kiandra along Snowy Mts. Hwy, 9.xii.1977, I.R. Telford 6909 (CBG). Victoria. Echo Flat, c. 2 km N of Lake Mountain summit, 21.xii.1983, S.J. Forbes 1911 (MEL, NSW); Baw Baw National Park. beside St Gwinear Link Trail about 500 metres from Loop Trail, 4.iii.2008, J.A. Jeanes 1930 (CANB, MEL, K, NSW); near summit of Mount Buller, E of Mansfield, 1.i.1996., A.R. Bean 9463 (BRI, MEL); on slopes around Mount Howitt, 6.i.1949, T.M. Whaite s.n. (NSW); The Gorge, Snowy Range - 3 km SW of airstrip, 26.xi.1980, N.G. Walsh 963 (MEL); Holmes Plain, southern Snowy Range, 19.xi. 1980; N.G. Walsh 978 (MEL); Buffalo Mountains, 1906, H.B. Williamson 1359 (MEL); Mt Hotham, 14.xii.1977, M. Gray 6843 (CANB); Mount Loch carpark area, near Mount Hotham, 2.xii.1986, P.G. Abell 235 & C. Herscovitch (NSW); near Cope Hut, Bogong High Plains, 21.xii.1970, L.A. Craven 1920 & K.L. Gunn (CANB, MEL); Bogong High Plains, 0.5 km NE of Mt Nelse South summit, 8.i.1993, N.G. Walsh 3484 (MEL); c. 900 m ESE of Mt McKay on a low rise, 17.xi.1997, M.F. Duretto 1258 (MEL); Mt. Bogong, on T-spur track, 29.xii.1964, M.U.M.C. s.n. (CBG); Mount Pinnibar, 24.ii.1973, A.C. Beauglehole 41581 (MEL).

Figure 5. *Asterolasia trymalioides* subsp. *areniticola*, flowering plant, type population, Morton National Park, New South Wales (photograph N. Walsh)

Distribution and habitat: The type subspecies occurs in alpine and subalpine vegetation from Lake Mountain in Victoria to Kiandra in New South Wales. It is very common on the Bogong High Plains in north-eastern Victoria, often in treeless grasslands and heathlands and extending into the alpine zone, but occasionally in open snow gum (*Eucalyptus pauciflora* subsp. *niphophila* (Maiden & Blakely) L.A.S.Johnson & Blaxell) woodland. In Kosciuszko National Park it does not occur in the alpine zone and is localised, having been recorded in open heathland in the Smiggins Hole area, Guthega, Burrumgubugee River valley, Happy Jacks Plain, Kiandra and footslopes of Mt Jagungal. Commonly associated species throughout its range include *Celmisia* spp., *Grevillea australis* R.Br., *Hovea montana* (Hook.f.) J.H.Ross, *Poa* spp., and *Kunzea muelleri* Benth.

Conservation status: Common across most of its range and (apart from ski resorts) occurs entirely within conservation reserves. Not currently rare or threatened but there are surprisingly few recent records from well-frequented places such as Mt Buffalo, and its distribution in NSW is very patchy. This subspecies is palatable to cattle (van Rees 1998) and is an obligate seeder – past land-use in the Australian Alps may have affected its current distribution. Applying IUCN (2012) criteria subsp. *trymalioides* could be considered 'near threatened' in that it currently does not qualify as endangered or vulnerable, but it is conceivable, through climate change or changes in management (e.g. recommencement of grazing), that it could qualify as threatened in the future.

Notes: Distinctive from the other subspecies in its low, spreading habit, leaves with broadly recurved margins, usually obscuring 20% or more of the abaxial leaf surface, in the relatively small flowers (petals generally <6 mm long, cf. >7.5 mm in other subspecies) and in the stigma lobes which are widely spreading (mostly >1.5 mm diam. c.f. <1.4 mm in other subspecies) at full expansion. On high, exposed mountains e.g. the summit area of Mt Nelse, Bogong High Plains, plants may be no more than c. 10 cm high and spread up to 50 cm diam. or more. In more sheltered sites, such as valleys of the Baw Baw plateau, shrubs may approach 1 m in height when occurring in taller heathlands. Victorian plants tend to have longer leaves than those in New South Wales (mean ± SE in Victoria = 5.8 ± 0.2 mm, in NSW = 4.5 ± 0.2 mm). Putative hybrids with subsp. *villosa* appear to occur in the Thredbo valley.

2. *Asterolasia trymalioides* subsp. *areniticola* K.L.McDougall and C.J.Hook, subsp. nov.

***Type*: NEW SOUTH WALES.** Morton National Park, c. 10 km NE of Nerriga, 400 m S of the Braidwood-Nowra Rd. Beneath electricity transmission lines, 6.x.2014, *N.G.Walsh* 8186 & *K.L.McDougall.* (holotype: MEL 2379919; isotypes: CANB, NSW).

Erect *shrub* to 1.5 (rarely to 2) m high; *hairs of leaves and branchlets* with stellae 0.6–0.8 mm diam. and stalks to 0.6 mm long; stems smooth and glabrous after c. 2 years of growth. *Leaves* ovate to obovate, sometimes suborbicular, 5.0–8.1 mm long (including petiole 0.8–2.1 mm), 2.1–4.3 mm wide, apex rounded, recurved margins obscuring up to 10% (rarely to 14%) of the lower surface; upper surface initially sparsely stellate-pubescent, but stellate hairs fallen by the time leaves are fully expanded, finally glabrous and ±shining, with scattered tubercles. *Sepals* 0.5–2 mm long; *petals* (6.0–)7.5–10.0 mm long, 3.5–5.1 mm wide, bright yellow; *staminal filaments* 4–6.3 mm long; *anthers* 1.0–1.5 mm long; *style* 3.0–4.8 mm long; *stigma* 0.6–0.8 mm diam. when fully expanded. Flowering: September–early December (Figs. 3, 5).

Specimens examined: **NEW SOUTH WALES.** Morton National Park; Main Road 4.5 km past Tolwong turn-off (at track to head of Ettrema Creek), 26.ix.2006, P. Carmen 304 & C. Hook (CANB, MEL); Pigeon House Range (near Nerriga), W of Jervis Bay, 14.ix.1954, E. Gauba s.n. (MEL); c. 4 km W of Tianjara Falls on the Nerriga-Nowra Road (close to the power lines), 11.x.1985, P. Ollerenshaw 1743 (CBG, NSW); 11.6 km along Touga Rd from Nerriga Rd, 2.x.2005, P. Carmen 271, P. Ollerenshaw & C. Hook (CANB, MEL, NSW); Touga Rd, 11.5 km north of Braidwood Rd, Morton National Park, 26.ix.2006, K.L. McDougall 1273 (CANB); Braidwood Rd, 4.5 km E of Touga Rd, Morton National Park, 26.ix.2006, K.L. McDougall 1274 (MEL); near Tullyangella Creek, tributary of Ettrema Creek, 28.i.1975, I. Olsen 2429 (NSW); 2 km S of Wilban Hill, Ettrema Plateau, W of Nowra, 15.iii.1969, B.G. Briggs 3005 (NSW).

Distribution and habitat: Apparently localised in the Budawang Range near Nerriga, south-eastern New South Wales (altitude 700–800 m), and perhaps endemic to Morton National Park. It is found in heathland typically growing in shallow soil over sandstone rock

slabs, occurring especially in areas of poor drainage. Associated species include *Acacia hamiltoniana* Maiden, *Allocasuarina distyla* (Vent.) L.A.S.Johnson, *Banksia spinulosa* Sm., *Dampiera stricta* (Sm.) R.Br., *Epacris microphylla* R.Br. var. *microphylla*, *Grevillea baueri* R.Br., *G. patulifolia* Gand. (Cav.) Druce, *Hakea teretifolia* (Salisb.) Britten, *Isopogon anemonifolius* (Salisb.) Knight, *Kunzea parvifolia* Schauer, *Lepyrodia anarthria* F.Muell., and *Pimelea linifolia* Sm.

Conservation status: Occasionally abundant and even co-dominant but apparently highly localised within Morton National Park. Estimated area of extent is approximately 30 ha, number of known populations is fewer than ten and total population estimated at c. 700 individuals. On these estimates, applying IUCN (2012) criteria it qualifies as vulnerable (VU). Observations and knowledge of biology of related species suggests that this is an obligate regenerator from seed. Populations are therefore vulnerable to fire intervals of shorter time than allows replenishment of the soil seed bank (approximately 3 years).

Notes: Differs from other subspecies of *A. trymalioides* in the adaxial surface of leaves being devoid of stellate hairs as soon as fully expanded, in the margins being only narrowly recurved (obscuring generally less than 10% of the leaf abaxial surface) and in the flowers with large (mostly 7.5–10 mm long), brightly coloured petals. It is apparently confined to poorly drained sandstone heaths of the Budawang Mountains.

3. *Asterolasia trymalioides* subsp. *villosa* K.L.McDougall and C.J.Hook, subsp. nov.

***Type*: AUSTRALIAN CAPITAL TERRITORY.** Namadgi National Park, Mt Scabby summit area, 9.xii.2013, *N.G.Walsh* 7992 (holotype: MEL 2378466; isotypes: CANB, K, NSW).

Erect to spreading shrub to 80 (rarely to 150) cm high;

Figure 6. *Asterolasia trymalioides* subsp. *villosa*, flowering plant, type population, Mt Scabby, Australian Capital Territory (photograph N. Walsh)

branchlets floccose, hairs with stellae (0.6)0.8–1.5 mm diam. and stalks (0.5–)1.0–1.3(–1.7) mm long above a dense indumentum of sessile stellate hairs; older stems glabrescent, but often retaining remnants of hair-stalks. *Leaves* ovate, or more commonly broadly ovate, broadly elliptic, orbicular or sometimes oblate, (4.2–)5.8–8.4(–10.5) mm long (including petiole 1.2–2.8(–4.0 mm)), 2.2–5.1 mm wide, apex rounded, revolute margins obscuring (2–)11–18(–31)% of the lower surface; upper surface initially stellate-pubescent, but finally tuberculate or sparsely hispid from the retained stubs of the stalked stellate hairs. *Sepals* 1–2 mm long; *petals* (6.5–)–8–10.7 mm long, 3.0–5.0 mm wide, bright yellow; *staminal filaments* 4.1–5.7 mm long; *anthers* 1.0–2.0 mm long; *style* (3.7–)4.7–6.0(–8.0) mm long (and often longer than stamens), *stigma* 0.9–1.2(–1.4) mm diam. when fully expanded. Flowering: October–December (Figs. 3, 6).

***Selected specimens (of 18) examined*: AUSTRALIAN CAPITAL TERRITORY.** 5ams Creek, c. 2 km S of Mt Kelly, 22.i.1992, A.M. Lyne 714, F.E. Davies, I.R. Telford & S. York (CANB, NSW); Scabby Range, Mount Scabby, 11.iii.1992, A.M. Lyne 727, P. Hewat & I.R. Telford (CANB, MEL, NSW, PERTH); Namadgi National Park, Mt Gudgenby, c. 400 m N of summit, 1.i.1995, N. Taws 444 (CBG); 5outhern 5ummit of Booroomba Rocks, W5W of Tharwa, 27.x.1970, R. Pullen 11038 (CANB); 3 km NW of Booroomba Rocks, 11.xii.1985, I.R. Telford 10127 & P. Beesley (CANB, MEL,NSW); Tennent District: c. 12 km E of Corin Dam, 13.xi.1982, L.G. Adams 3904 & J. Hook (CANB); Namadgi National Park. 5entry Box Mountain, c. 450 m 5W from summit, 12.xii.2013, N.G. Walsh 8102 (CANB, MEL, NSW); Namadgi National Park, Mt 5cabby summit area, 9.xii.2013.NEW 5OUTH WALES. Mt. Tinderry near Michelago, 7.x.1950, J. McNear s.n. (CANB); Tinderry Nature Reserve, Tinderry Twin Peak, c. 50 m W of summit, 19.v.1992, F.E. Davies 1728, S. Donaldson & S. Triffitt (CBG); Lower Little Thredbo River near Thredbo River, 2.xii.1981, J. Thompson 4153 (NSW); Little Thredbo River, 14.xi.2007, K.L. McDougall 1305 & L. Broome (MEL); Eastern side of Thredbo River, c. 500–750 m downstream of confluence with Little Thredbo River, 10.vi.2013, C. Cosgrove s.n., C. Hook & P. Carmen (MEL); Near junction of Thredbo and Little Thredbo Rivers, viii.1949, A.B. Costin s.n. (N5W 654466). **VICTORIA.** Bowen Range, N end, 4.iii.1971, A.C. Beauglehole 37197 (MEL).

Distribution and habitat: Occurs in shrublands, subalpine heaths and shrubby snow-gum woodlands of elevated rocky (usually granitic) sites of Namadgi National Park in the ACT, the Tinderry Mountains, with an outlying population in the Bowen Range (near Cabanandra) in eastern Victoria. Altitude range is 1100–1700 m. Commonly associated species include *Callistemon pallidus* (Bonpl.) DC., *Grevillea diminuta* L.A.S.Johnson, *Eucalyptus pauciflora* subsp. *debeuzevillei* (Maiden) L.A.S.Johnson & Blaxell, *Epacris robusta* Benth., *Kunzea muelleri* Benth., *Leptospermum namadgiensis* Lyne, *L. micromyrtus* Miq., *Oxylobium ellipticum* (Vent.) R.Br. The plants in the Thredbo valley, which are possible hybrids with subsp. *trymalioides*, grow in riparian open woodland with *Eucalyptus pauciflora* Sieber ex Spreng. subsp. *pauciflora* and *Leionema phylicifolium* (F.Muell.) Paul G. Wilson. The habitat of the only Victorian locality is unknown.

Conservation status: Scattered in suitable habitat in ACT and NSW, exceedingly rare in Victoria and not re-collected from the Bowen Range since 1971, despite several searches of the area. Estimated area of extent is approximately 80ha, number of known populations is around ten and the total population is estimated at c. 800 individuals. On these estimates, applying IUCN (2012) criteria it qualifies as vulnerable (VU). Observations and knowledge of biology of related species suggests that this is an obligate regenerator from seed. Populations are therefore vulnerable to fire intervals of shorter time than allows replenishment of the soil seed bank (approximately 3 years). In Victoria it may be extinct.

Notes: Differs from other subspecies of *A. trymalioides* in the adaxial surfaces of leaves retaining stellate hairs until after full expansion and the stellae being wider (mostly 0.8 mm diam. or more) and with longer (mostly >1 mm long) stalks, and in the flowers with large (mostly 7.5–10 mm long), brightly coloured petals.

Apart from several clustered populations in the mountains of Namadgi National Park of the ACT that border NSW, this subspecies is characterised by widely spaced and isolated populations (Fig. 2). The ACT populations are separated from the Tinderry population by 40 km, from the Thredbo valley (where putative hybrids with subsp. *trymalioides* occur) by about 80 km and from the Bowen Range by 140 km.

Acknowledgements

Some fieldwork in Namadgi National Park was undertaken during a Bush Blitz survey (Bush Blitz

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Supplementary material. Morphometric data used in the analyses.

Accession	Primary collector	Max. stalk length (mm)	Max. stellae radius (mm)	Leaf length (mm)	Leaf width (mm)	Leaf shape (lamina length:width)	Obscur-ation (mm)	Petiole length (mm)	Petal length (mm)	Petal width (mm)	Staminal filament length (mm)	Anther length (mm)	Style length (mm)	Stigma width (mm)
CAN8207920	L. Craven	0.0	0.5	6.9	2.2	2.5	0.5	1.5	5.4	2.0	4.4	1.5	1.8	2.0
CANB252057	M. Gray	0.1	0.5	7.0	2.1	3.2	0.5	0.4	5.0	1.9	4.2	1.4	2.0	2.0
CANB335709	R. Pullen	1.1	1.1	8.3	4.6	1.3	0.2	2.2	8.0	3.8	4.2	1.5	5.1	1.4
CANB343351	N. Walsh	0.1	0.4	7.6	3.3	1.5	0.6	2.7	5.1	2.6	4.0	1.8	1.8	2.1
CANB779865	R. Purdie	1.0	1.5	8.2	4.7	1.2	0.8	2.5	7.0	4.5	4.1	1.4	4.1	0.9
CANB882927	K. McDougall	0.3	0.6	7.3	4.4	1.5	0.5	0.8	8.6	4.8	4.8	1.1	4.8	0.7
CANB882928	K. McDougall	0.1	0.6	6.7	3.6	1.4	0.3	1.6	9.1	5.3	6.3	1.1	4.1	0.8
CANB882931	K. McDougall	0.3	0.6	7.3	3.3	1.6	0.4	1.9	8.1	4.6	5.2	1.2	4.7	0.7
CANB882935	K. McDougall	0.9	1.3	10.5	4.9	1.6	0.8	2.7	10.1	4.9	5.1	1.8	4.8	1.3
CANB882936	K. McDougall	0.4	0.7	8.1	3.2	2.0	0.7	1.9	5.1	2.5	5.2	1.1	3.0	1.3
CAN8882937	K. McDougall	0.5	0.5	4.9	2.4	1.5	0.5	1.1	5.5	2.5	3.1	1.3	3.4	2.0
CANB882938	K. McDougall	0.4	0.9	7.2	3.2	1.6	0.5	1.9	5.3	2.2	3.5	1.1	3.2	1.6
CANB882939	K. McDougall	0.0	0.4	5.8	2.5	2.0	0.5	0.8	5.0	2.2	3.2	1.4	2.1	2.1
CANB882940	C. Hook	0.9	1.3	10.2	4.3	1.7	0.7	2.8	10.7	5.0	5.7	1.4	5.1	1.2
C8G15133	E. Carroll	0.0	0.4	6.3	2.5	1.8	0.5	1.7	4.0	2.5	4.5	1.3	1.4	2.5
C8G17937	E. Carroll	0.0	0.4	7.1	3.0	1.8	0.5	1.7	4.9	2.5	4.2	1.1	2.8	1.7
C8G7708532	I. Telford	0.1	0.4	5.8	2.6	1.7	0.5	1.4	4.8	2.5	4.2	1.0	2.1	1.7
C8G8311280	N. Walsh	0.0	0.6	5.7	2.3	2.0	0.3	1.2	4.7	2.6	4.0	1.4	1.7	1.8
C8G8505034	I. Telford	1.0	0.9	8.6	4.2	1.3	0.5	3.1	8.0	3.8	4.8	1.4	5.5	1.2
C8G8704215	I. Telford	0.0	0.3	7.7	2.2	2.9	0.3	1.2	5.8	2.8	5.0	1.3	2.5	2.0
CBG8764	M.U.M.C	0.0	0.4	8.2	1.9	3.2	0.5	2.2	5.1	2.8	4.6	1.3	2.4	1.9
CBG9209394	A. Lyne	1.3	1.1	7.3	3.9	1.2	0.6	2.6	8.5	3.9	4.4	1.6	6.0	1.2
MEL2014452	N. Walsh	0.1	0.6	5.7	1.9	2.6	0.3	0.8	5.1	2.5	4.5	1.8	1.3	1.9
MEL2049237	M. Duretto	0.0	0.3	8.2	2.3	2.8	0.7	1.7	6.0	3.0	6.5	1.7	3.0	1.9
MEL2097876	J. Luehmann	0.0	0.4	6.7	2.4	2.3	0.5	1.2	5.5	3.5	4.5	2.0	2.0	1.5

Accession	Primary collector	Max. stalk length (mm)	Max. stellae radius (mm)	Leaf length (mm)	Leaf width (mm)	Leaf shape (lamina length:width)	Obscur-ation (mm)	Petiole length (mm)	Petal length (mm)	Petal width (mm)	Staminal filament length (mm)	Anther length (mm)	Style length (mm)	Stigma width (mm)
MEL2369167	K. McDougall	1.3	0.6	6.3	3.1	1.5	0.5	1.5	7.0	2.6	5.5	1.0	3.7	1.2
MEL2369168	K. McDougall	0.2	0.6	5.6	3.1	1.2	0.6	1.7	5.6	3.1	5.1	1.1	4.0	2.0
MEL269867	A. Bean	0.1	0.7	8.1	2.8	2.3	0.5	1.4	5.4	2.0	4.7	1.2	1.3	1.9
MEL628627	N. Walsh	0.0	0.5	6.7	2.5	2.1	0.6	1.5	5.0	3.0	4.5	1.4	3.0	2.3
MEL641165	N. Walsh	0.0	0.5	6.0	2.1	2.3	0.6	1.2	5.1	2.0	3.9	1.5	1.5	1.5
MEL641253	N. Walsh	0.1	0.5	6.7	2.3	2.1	0.4	1.8	6.0	3.0	4.5	1.5	3.0	1.8
MEL665702	S. Forbes	0.0	0.4	6.8	2.3	2.1	0.5	1.8	5.0	3.0	6.0	1.5	3.5	1.9
MEL708607	F. Mueller	0.0	0.5	6.9	2.8	2.1	0.8	1.1	4.8	2.5	3.9	1.7	1.4	2.1
MEL708608	F. Mueller	0.2	0.7	7.8	2.6	2.2	0.6	2.0	4.6	2.8	4.0	1.5	2.7	1.7
MEL709151	E. Gauba	0.3	0.4	6.7	3.4	1.5	0.2	1.5	7.5	4.0	4.0	1.4	3.5	0.6
NSW208711	P. Abell	0.3	0.6	7.7	2.7	2.3	0.8	1.3	4.5	2.7	4.3	1.4	2.2	1.5
N5W262369	unknown	0.1	0.5	6.2	2.1	2.3	0.6	1.3	4.0	2.0	3.8	1.2	4.5	1.5
N5W262413	J. Thompson	0.7	0.7	6.2	2.7	1.7	0.8	1.7	6.5	3.5	4.5	1.5	6.0	1.0
NSW505045	E. Norris	0.1	0.5	8.0	2.3	2.8	0.4	1.7	5.5	3.0	4.0	1.5	3.0	2.8
N5W654460	A. Lyne	0.8	1.1	8.2	3.8	1.3	0.6	3.0	10.0	5.0	5.5	2.0	6.0	1.2
N5W654521	B. Briggs	0.3	0.3	7.8	3.5	1.7	0.4	2.0	7.5	3.5	4.0	1.0	4.5	0.8
N5W654525	J. Armstrong	0.0	0.4	8.3	2.6	2.9	0.8	0.9	5.5	2.6	5.5	1.6	1.6	1.6
N5W654526	B. Briggs	0.1	0.5	6.7	2.8	1.8	0.5	1.5	6.0	2.5	4.5	1.2	2.0	1.5
NSW654527	N. Ford	0.1	0.6	7.5	2.8	2.1	0.7	1.5	6.0	2.5	6.0	1.5	4.0	2.0
NSW654528	T. Whaite	0.1	0.5	7.5	2.5	2.0	0.3	2.5	5.0	2.5	4.5	1.8	3.0	1.8
NSW654530	F. Mueller	0.1	0.7	7.0	2.5	2.2	0.8	1.5	5.5	2.5	4.5	1.5	2.0	1.5
NSW70019	T. Stead	0.1	0.7	7.0	2.2	2.7	0.6	1.2	5.0	2.0	5.2	1.7	3.0	1.7
NSW70048	T. Stead	0.2	0.6	7.1	1.9	2.9	0.7	1.4	5.5	2.0	3.5	1.2	3.0	1.5

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False Polygonaceae smut: increasing knowledge about *Sphacelotheca polygoni-serrulati* Maire in Australia

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Introduction

The study of interactions between fungi and plants is important because fungi are both significant plant mutualists and disease agents. In the buckwheat family, Polygonaceae, examples of beneficial interactions include ectomycorrhizal fungal symbionts on roots of *Bistorta vivipara* (L.) Delarbre (Mühlmann *et al.* 2008) and arbuscular mycorrhizae on *Fagopyrum* Mill. (Likar *et al.* 2008). These root-associated fungi are known to benefit plant partners through increased nutrient, mineral and water up-take in exchange for carbohydrates (Wang & Qiu 2006).

However, some Polygonaceae clades, including Fagopyreae, Persicarieae, Polygoneae, and Rumiceae (Fig. 1), are parasitised by rust and false smut fungi belonging to the Pucciniomycotina (Microbotryaceae) and the distantly related Ustilaginomycotina (*Entyloma* de Bary, *Melanopsichium* G. Beck, and *Thecaphora* Fingerh.) (Vánky 1994; Vánky & Oberwinkler 1994; McKenzie 1998; Vánky 2002; Kemler *et al.* 2006; Piątek *et al.* 2012; Vasighzadeh *et al.* 2014; Klenke & Scholler 2015). False smuts were split from *Ustilago* (true smuts), which use monocots such as Poaceae as hosts, based on morphological (Langdon & Fullerton 1978; Blanz & Gottschalk 1984) and molecular data (Aime *et al.* 2014). This parasitism could have an application in controlling invasive plant species, since fungal leaf endophytes from *Persicaria amphibia* (L.) Delarbre may

Abstract

We report the first record of *Sphocelotheco polygoni-serruloti* Maire on live *Persicorio decipiens* (R.Br.) K.L.Wilson flowers and also on some herbarium collections for the Australian Capital Territory (ACT) and the state of Victoria, dating as far back as 1956. Our determination is based on molecular, macro-, and micro-morphological spore ornamentation characters. We also clarify phylogenetic relationships of Polygonaceae hosts with regard to *Sphocelotheca* and related mycoparasites. Our findings show the importance of living and herbarium collections as data sources for increasing our knowledge about interactions of plants and fungi.

Key words: anther smut, Caryophyllales, Microbotryaceae, plant parasite, teliospore ornamentation, urban biodiversity

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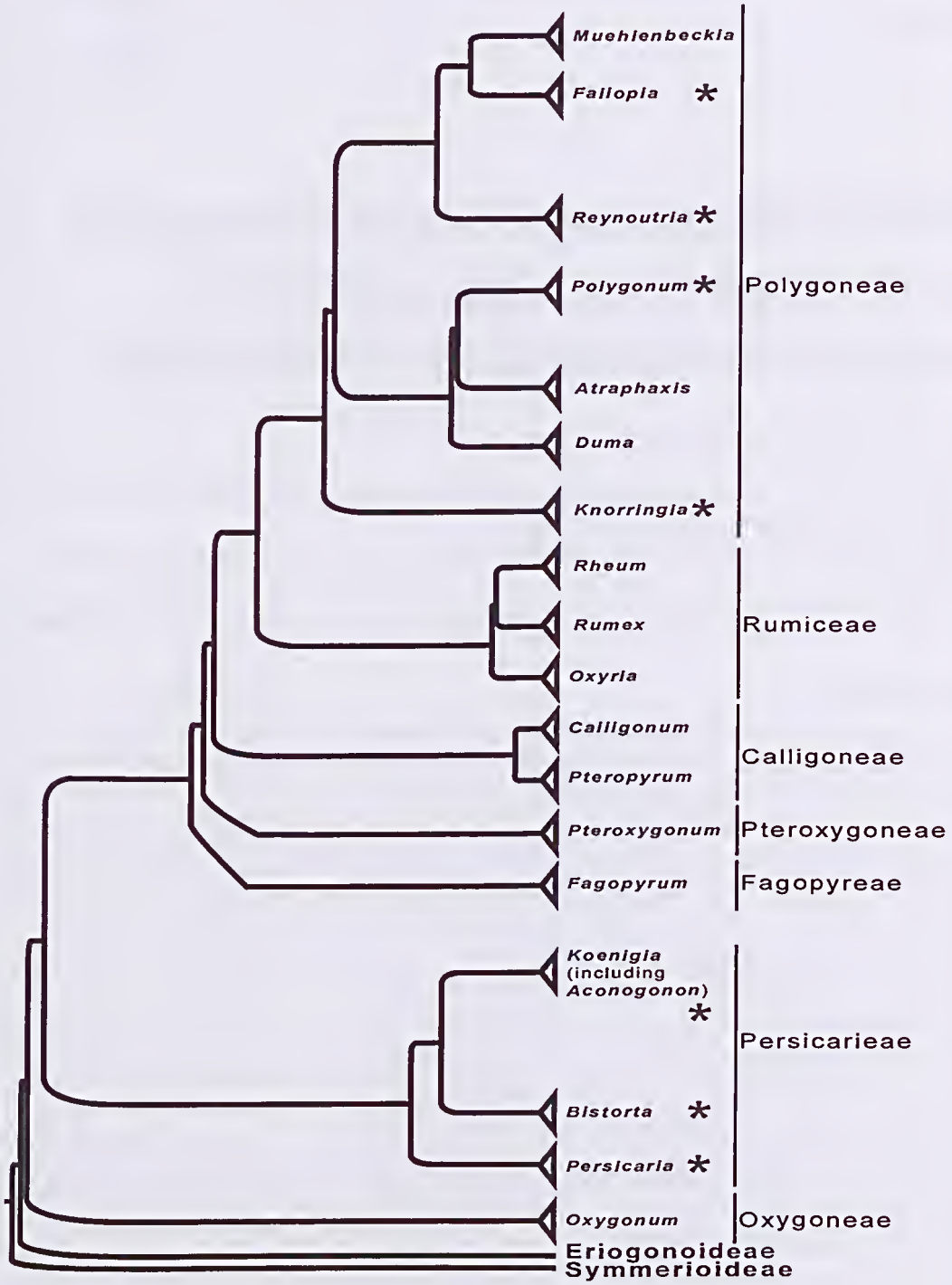
Figure 1. Cladogram of Polygonoideae (modified from Schuster et *al.* 2015) marking the position of *Polygonum* and genera split from *Polygonum* s.l. with asterisks. Polygonaceae tribes are indicated by bars to the right of the tree.



increase the effectiveness of third-party rust fungi with the potential to control the invasive plant *Reynoutria japonica* Houtt. (Kurose *et al.* 2012).

Rusts (*Puccinia* Pers. and *Uromyces* (Link) Unger) occur on leaves, stems and roots of Rumiceae and Polygoneae, while false smuts (mainly Microbotryaceae including *Liroa* Cif., *Microbotryum* Lév., *Sphacelotheca* de Bary, and *Zundeliomyces* Vánky) usually inhabit anthers and ovaries of all four of these Polygonaceae tribes (Kemler *et al.* 2006). Since parasitic fungi often depend on specific host plants (Lutz *et al.* 2005), knowledge of host plant identity and phylogeny is critical for the identification and interpretation of the evolutionary history of associated mycoparasites. Recent molecular analyses of the buckwheat family have clarified the phylogeny of this diverse plant group (e.g., Sanchez *et al.* 2009; Schuster *et al.* 2015). These contributions aid in the assessments of the taxonomy and evolution of their fungal parasites. To facilitate interpretation of the complicated *Polygonum* s.l. nomenclature, Fig. 1 gives the current phylogenetic position of genera split from it. Appendix 1 lists species of Microbotryaceae with their Polygonaceae hosts reported in the literature (molecular and morphological records) and shows currently accepted names and clades for the latter.

For example, the monotypic *Liroa emodensis* Berk. (treated as *Microbotryum emodensis* (Berk.) M.Pipenbr. by some) parasitises *Persicaria chinensis* (L.) H.Gross (Kemler *et al.* 2006). The monotypic *Zundeliomyces polygoni* Vánky (possibly a synonym of *Melanopsichium austroamericanum* (Speg.) Beck) uses *Koenigia alpina* (All.) T.M.Schust. & Reveal as host (Vánky 1987). Species of *Sphacelotheca* also only infect Polygonaceae (Vánky 1987, 2002; Vánky & Oberwinkler 1994; Almaraz *et al.* 2002), while species of *Microbotryum* use a broad range of eudicotyledonous host species. In addition to Polygonaceae, *Microbotryum* infects members of Asteraceae, Caprifoliaceae, Caryophyllaceae, Gentianaceae, Lamiaceae, Lentibulariaceae, Onagraceae, Portulacaceae, and Primulaceae (Vánky & Shivas 2008). The life history of these fungi has been linked to that of pollinators, which function in vectoring fungal spores between plants (Kemler *et al.* 2006).

Members of Microbotryaceae differ in several morphological characters such as spore colour, presence or absence of teliospore catenation at some developmental stage, a columella, and peridium (Table 1), but all have septa lacking pores at maturity (Bauer *et al.* 1997). Presence or absence of a peridium is a difficult character, because of confusing statements

Figure 2. Field shot of *Persicaria decipiens* (*Stajsic 7332*) with false smut growing on ovaries. *Sphacelotheca polygoni-serrulati* axillar columella and split peridium indicated by arrows (C = columella and P = peridium).

Table 1. Morphological characters used to distinguish genera of Microbotryaceae.

	Spore mass colour	Columella	Peridium	Immature teliospore catenation
Liroo Cif.	purplish brown	absent	present (but see Vánky 2002)	absent
Microbotryum Lév.	purplish brown	absent	absent	absent
Sphacelotheca de Bary	purplish brown	present	present	present
Zundeliomyces Vánky	pale ochre	absent	present	present

for *Liroa* and *Microbotryum*. Vánky (1998) and Vánky & Shivas (2008) use the absence of a peridium to separate *Liroa* and *Microbotryum* from *Sphacelotheca* in keys for these genera, but the description of *Microbotryum* in these works refers to the presence of peridia (peridium "around" and globose respectively). Likely this is a typographical error, and both the key and description of *Microbotryum* in Vánky (2002) note the absence of a peridium. However, Piepenbring (2002) notes the presence of a peridium in *Liroa* and, though he does not explicitly refer to a peridium, Vánky's (2002) description of *Liroa* notes irregularly globose, stalked swellings that are at first green, which suggests participation of host plant tissues in sorus formation.

In addition to discussing the classification of Microbotryaceae and Polygonaceae phylogeny with regard to parasitism by these false smuts, we report here on new records of *Sphacelotheca polygoni-serrulati* in Australia. This was prompted by finding large populations of *Persicaria decipiens* (R.Br.) K.L.Wilson (Polygonaceae) at the Royal Botanic Gardens Victoria (RBGV), Melbourne, infected with a showy purplish brown smut inhabiting the flowers (Figs. 2 & 3). We identified the fungus using morphological and molecular methods to document the biodiversity supported by this urban environment.

Material and methods

Specimens examined

Although some of the *Persicaria decipiens* populations at RBGV Melbourne were originally planted, most are

Figure 3. Close-up of *V. Stajsic 7254* with *Sphocelotheco polygoni-serruloti* axillar columellae emerging from *Persicaria* flowers and covered with purplish brown teliospores.

self-established. Our collections of *S. polygoni-serrulati* were gathered from self-established host populations. Samples of *P. decipiens* parasitised by false smut from RBGV Melbourne used to examine micro- and macro-morphological characters and for molecular data generation were: VICTORIA. *V. Stajsic 7254* (MEL 2383469A) and *T.M. Schuster TMS14-30A* (MEL 2385255A).

In addition, herbarium specimens of *Persicaria* Mill. at MEL from all Australian states and territories were checked for the presence of false smut. These include ca. 1100 sheets of *P. attenuata* (R.Br.) Soják, *P. barbata* (L.) H.Hara, *P. capitata* (Buch.-Ham. ex D.Don) H.Gross, *P. chinensis* (L.) H.Gross, *P. decipiens*, *P. dichotoma* (Blume) Masam., *P. hydropiper* (L.) Delarbre, *P. lapathifolia* (L.) Delarbre, *P. maculosa* Gray, *P. odorata* (Lour.) Sojak, *P. orientalis* (L.) Spach, *P. praetermissa* (Hook. F.) H.Hara, *P. prostrata* (R.Br.) Soják, *P. strigosa* (R.Br.) Nakai, and *P. subsessilis* (R.Br.) K.L.Wilson.

Morphology

An Olympus SZX16 stereo microscope with camera setup DP71 was used to examine smut morphology and sporulation site in the flowers of *Persicaria decipiens*. A JCM-6000 NeoScope benchtop scanning electron microscope (SEM; Coherent Scientific, Adelaide) was used to observe the smut spores. A portion of a silica gel dried spore mass was spread over a conducting carbon tab and sputter coated with gold without any further treatment. Images (Figs. 4 & 5) were obtained using high vacuum, SEI (secondary electron image), 15kV, and standard probe current.

Sequence Data

Total genomic DNA was extracted from smut samples with the Sigma-Aldrich Extract-N-Amp kit (Sigma-Aldrich, Australia) following manufacturer protocols. To place our smut samples growing on *Persicaria decipiens* at the RBGV within a molecular phylogeny, we amplified and sequenced the nuclear internal transcribed spacer (ITS) region with the primer pair ITS1f and ITS4 (White *et al.* 1990), and the large subunit (LSU) region of the rDNA using the primers LROR and LR3 (Vilgalys & Hester 1990). MyTaq Red DNA polymerase (Bioline, Melbourne) was used for PCR. The following settings were used for PCR: 1 min of 94°C denaturation step followed by 35 cycles of 94°C for 1 min, 55°C for 30 sec and 72°C for 2 min, and a final extension step of 72°C for 7 min. Primers and single stranded DNA were cleaned from

Figure 4. Scanning electron micrograph (*T.M. Schuster 14-30A*) of a spore mass of *Sphacelotheca polygoni-serrulati* with clearly visible disjunctors (one marked with an arrow), which separate multiple spores initially strung together.

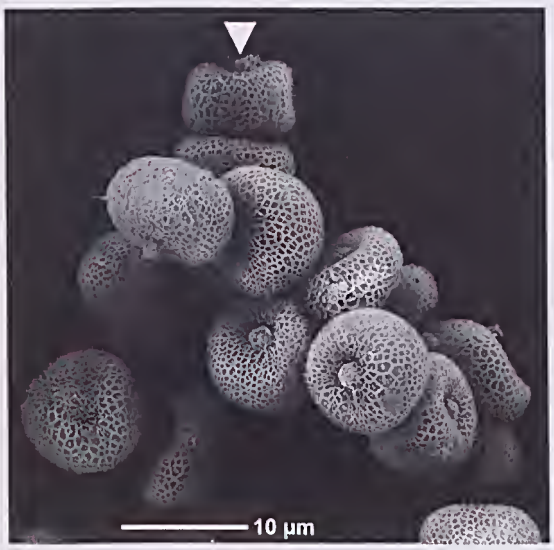
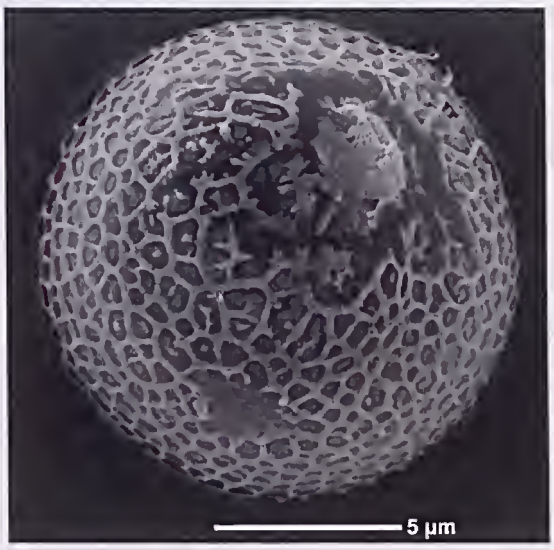


Figure 5. Scanning electron micrograph of teliospore (*T.M. Schuster 14-30A*) with reticulate ornamentation and disjunctor characteristic for *S. polygoni-serrulati*. Reticulum interspaces are irregularly sized and shaped and occasionally feature 1–few warts. The muri are shallow (as compared to some species of *Microbotryum*).



PCR products with exonuclease and arctic phosphatase and amplicons were Sanger sequenced bidirectionally on an AB3730xl analyser (Macrogen, Korea). Sequences were trimmed and assembled using Geneious v.7.0.6. (Biomatters, 2014) and sequence identity was assessed using the Blast algorithm (Altschul *et al.* 1997) and GenBank database (http://www.ncbi.nlm.nih.gov/genbank). Resulting sequences from our smut samples have been deposited in GenBank with the accession numbers: KP311405 (ITS), KP311345 (LSU) for *T.M. Schuster TMS14-30A* and KP311404 (ITS), KP311344 (LSU) for *V. Stajsic 7254*.

Sequence Analysis

Newly generated sequences and related sequences downloaded from GenBank were aligned using Muscle (Edgar 2004). For the ITS region 20 ingroup and two outgroup taxa were included in the analysis. For the LSU region 33 ingroup and one outgroup taxon were included. Due to an incomplete overlap of sampled taxa between the two datasets, we analysed them independently. Maximum Likelihood (ML) analyses were run on the CIPRES Science Gateway v.3.3. computer cluster (Miller *et al.* 2010) using RAxML-Hpc2 v.8.0.24. (Stamatakis 2006). Options selected for the RAxML analyses were a GTR GAMMA model and a GtrCat model for 1000 rapid Bootstrap searches. Tree files were exported and edited with FigTree v.1.4.1 (Rambaut 2014). Clade support values in text and Figs. 6 & 7 are shown as percent bootstrap support from the ML analyses.

Results

Specimens on which *Sphacelotheca* was found

Host: *Persicaria decipiens*. AUSTRALIAN CAPITAL TERRITORY. Junction of Brindabella and Lee Creek Road, 14.iv.1966, *N.T. Burbidge 7611* (MEL 1551940B). VICTORIA. Mead, xii.1956, *R. Schier s.n.* (MEL 2385252A); Captain Cook National Park. W side of Thurra River, NNE of Cape Everard, 11.xii.1969, *A.C. Beauglehole 32310[A] & E.W. Finck* (MEL 2385254A); Murray Valley. Kanyapella Wildlife Reserve, near Echuca, 13.x.1990, *E.A. Chesterfield 2680[A]* & N. Disken (MEL 2385253A); South Yarra. Royal Botanic Gardens Melbourne. Ornamental Lake, on E side of Long Island, 31.x. 2014, *V. Stajsic 7254 & L. Hancock* (MEL 2383469A); Royal Botanic Gardens Melbourne. Long Island, 9.xi.2014, *T.M. Schuster TMS14-30A* (MEL 2385255A); South Yarra. Royal Botanic Gardens Melbourne. Ornamental Lake, on E side of Long Island, 11.xi.2014, *V. Stajsic 7259* (MEL 2383475A, BRIP, VPRI); South Yarra. Royal Botanic Gardens Melbourne. Ornamental Lake. A-Gate Wetlands, 24.xi.2014, *V. Stajsic 7332* (MEL 2387398A, DAR).

Morphology

Examination with a stereo microscope revealed peridia and columellae on host plant ovaries with a powdery brown, slightly purple-tinted spore mass (Fig. 3). In addition, some teliospores were catenate when not fully developed and connected by disjunctors, later becoming solitary and usually with attached disjunctors, they lacked polar caps, and spores were mostly spherical or subspherical, 8–12(–15) × 8–12 µm, and had a sculpted surface.

Scanning Electron Microscope imaging showed conspicuous disjunctors and reticulate ornamentation of the teliospores (Fig. 4 & 5). Interspaces between the reticulations, with shallow muri, were irregularly shaped and sized, and some had 1–few warts. Subspherical, torus-shaped spores were occasionally catenate (Fig. 4).

Phylogenetic Analysis

The ITS alignment consisted of 679 characters including 344 that were constant and 98 that were parsimony-informative, whereas the LSU alignment included 889 characters of which 799 were constant and 38 were parsimony informative. The Akaike information criterion indicated that GTR+I+Γ was the most appropriate nucleotide substitution model for ML analyses. The ITS (Fig. 6) and LSU (Fig. 7) ML topologies were congruent with each other and place our samples in a well-supported clade composed of other *Sphacelotheca* isolates, and distinct from *Microbotryum*. In addition, *Liroa* is distinct from *Microbotryum* in our analyses.

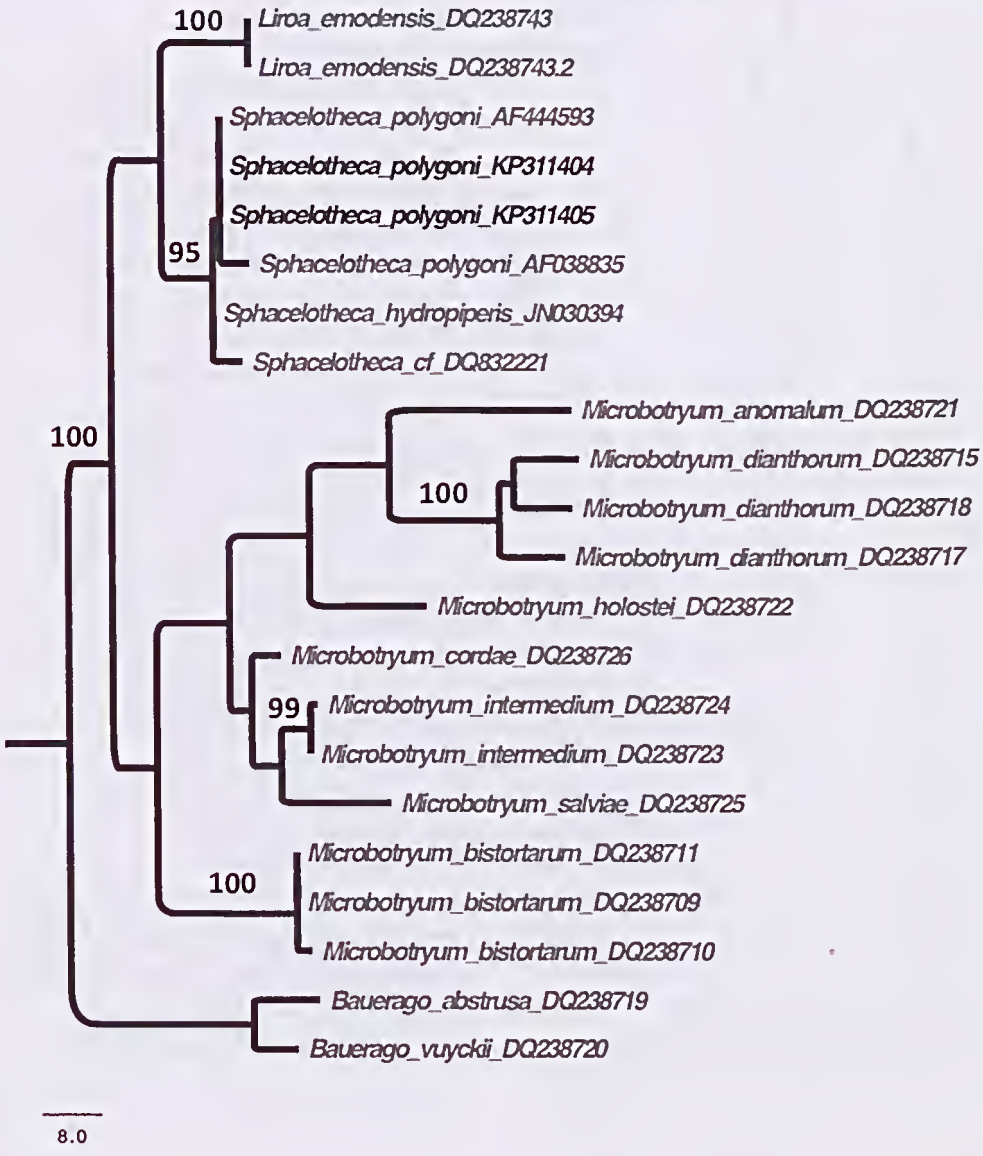
Discussion

New records of *Sphacelotheca polygoni-serrulati* in Australia

Our molecular (Figs. 6 & 7) and morphological results corroborate each other and show that the fungus infecting flowers of *Persicaria decipiens* at the RBGV is the

false smut *Sphacelotheca polygoni-serrulati*; establishing the first report of this fungus in the state of Victoria. The smut's macro-morphology (Figs. 2 & 3) shows columellae and peridia growing from the *Persicaria decipiens* ovaries and including the purplish brown smut spores characteristic of species of *Sphacelotheca*. Micro-morphological characters revealed by SEM (Figs. 4 & 5) show that the smut spores have clearly visible disjunctors plus the reticulate and sparsely warty ornamentation characteristic of *S. polygoni-serrulati* (Demel *et al.* 1985). *Sphacelotheca polygoni-serrulati* is currently the only species of *Sphacelotheca* recorded in Australia, where it has now been reported from all states except the Northern Territory and Queensland. Since *P. decipiens* occurs in these areas, it is likely that *S. polygoni-serrulati* may still be found there. Other than Australia, *P. decipiens* occurs in Africa, temperate Asia, southern Europe, and New Zealand (National Plant

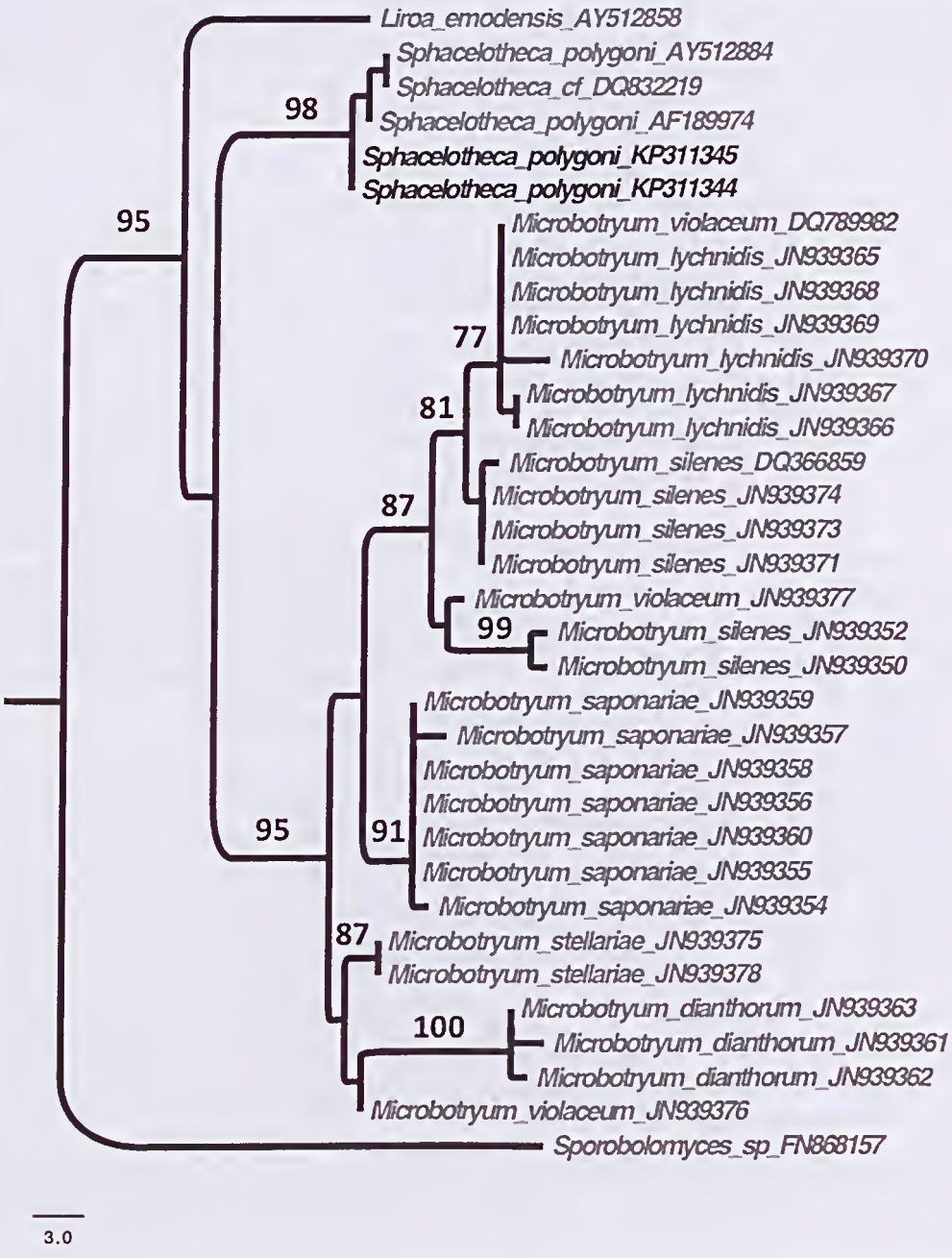
Figure 6. Most likely tree (ln -2327.053) based on RAxML analysis of the ITS rDNA region of 22 taxa. *Bauerago* was included as outgroup. This phylogenetic tree shows the placement of our samples from the Royal Botanic Gardens Victoria (shown in black text) and that they cluster together in a clade having high bootstrap support, which includes other collections of *Sphacelotheca*. Sequences AF444593 and AF038835 are actually *S. polygoni-persicariae*.



Germplasm System 2005; Allan 1982) and *S. polygoni-serrulati* now has been reported throughout most of this host range (Piątek *et al.* 2012; Appendix 1). Notably, neither *P. decipiens* nor *S. polygoni-serrulati* have been reported from the Americas, though *S.* cf *hydropiperis* occurs on *Persicaria acuminata* (Kunth) M. Gómez and *P. punctata* (Elliott) Small in South America (Piepenbring 1996).

We examined all Australian-collected specimens of *Persicaria* at MEL, because Piątek *et al.* (2012) show that *S.*

Figure 7. Most likely tree (ln -1924.234) based on RAxML analysis of the LSU rDNA region of 34 taxa. *Sporobolomyces* was included as outgroup. This phylogenetic tree shows the placement of our samples from the Royal Botanic Gardens Victoria (shown in black text) and that they cluster together in a clade with high bootstrap support, which includes other collections of *Sphacelotheca*. The sequence AF189974 is of *S. polygoni-persicariae*.



polygoni-serrulati also occurs on other species of *Persicaria* outside of Australia (e.g., *P. barbata*, *P. hydropiper*, *P. maculosa*, and *P. pulchra* (Blume) Soják). We found an additional specimen of *P. decipiens* from the ACT infected with *S. polygoni-serrulati*, which is the first report for this territory, and a further three Victorian specimens, with the earliest specimen dating to 1956. None of the other species of *Persicaria* examined at MEL were parasitised by *Sphacelotheca*, but a search of *Persicaria* material at other Australian herbaria may yield additional records. Since *S. polygoni-serrulati* has previously been recorded from Western Australia, South Australia, New South Wales, Tasmania, and northern New Zealand (Vánky & Shivas 2008; McKenzie & Vánky 2001), it is not unexpected that this species occurs in the ACT and Victoria, and it is surprising that it has been overlooked so far. On the other hand, a search of the VPRI collections yielded only a single 1893 specimen from Launceston, Tasmania, *L. Rodway 3109* (VPRI; Jacky Edwards pers. comm. 2014; Vánky & Shivas 2008). This might indicate reluctance by botanists to collect clearly diseased plant material for accessioning into herbaria, which might skew the distributional data for pathogenic fungi.

Microbotryaceae and host plant phylogeny

With regard to Microbotryaceae phylogeny, Kemler *et al.*'s (2006) results showed that *Liroa* and *Sphacelotheca* may actually be nested in a monophyletic *Microbotryum*, though clade support values varied considerably depending on alignment method chosen. In our ML analyses, the LSU data show that *Sphacelotheca* (98% bootstrap support) and *Microbotryum* (95% bootstrap support) form well-supported, separate clades (Figs. 6 & 7). ITS data suggest that accessions of *S. polygoni-serrulati* form a distinct clade, though there is no support for this relationship. *Liroa* is not included in *Microbotryum* in either analysis and may be sister to *Sphacelotheca* (ITS) or sister to both (LSU), but further studies are needed to determine this relationship.

Kemler *et al.* (2006, 2009) also showed that affinity of *Microbotryum* for Polygonaceae has likely arisen multiple times across the evolutionary history of these groups and that Persicarieae may have been the first eudicot lineage parasitised by these false smuts. Since this lineage infects all constituent genera of Persicarieae (Fig. 1), it may have co-evolved with the ancestor of Persicarieae. Kemler *et al.* (2006, 2009) also showed that another *Microbotryum* lineage that uses additional eudicot families also parasitises Polygoneae (*Fallopia* Adans. s.s. and *Polygonum* L. s.s.), Persicarieae (*Persicaria* only), and Rumiceae (*Oxyria* Hill and *Rumex* L.). These authors and Oberwinkler (2012) suggested that evolutionary trends in host plant preference of species of *Microbotryum* infecting Caryophyllaceae is narrowly specific, but that it is broad for Polygonaceae. This might actually not be the case and may have been determined by using an obsolete taxonomic concept of *Polygonum* (in the broad sense; Fig. 1). Based on molecular and morphological characters, *Polygonum* s.l. is not a monophyletic group and *Bistorta*, *Fallopia*, *Koenigia* sensu Schuster and Reveal (including *Aconogonon*), *Persicaria*, and *Reynoutria* are monophyletic genera that are not closely related to *Polygonum* s.s. (e.g., Sanchez *et al.* 2009; Schuster *et al.* 2015). Hence, species of *Microbotryum* and *Sphacelotheca* may actually be more host specific than previously thought, at least at the generic level. For example, *M. bistortarum* (DC.) Vánky parasitises both *Bistorta officinalis* (L.) Delarbre and *B. vivipara* (L.) Delarbre, and *M. bosniacum* parasitises *Koenigia alpina* and *K. songarica* (Schrenk ex Fisch. & C.A.Mey.) T.M.Schust. & Reveal (Chlebicki 2006). Both *Bistorta* and *Koenigia* sensu Schuster and Reveal lack detailed phylogenies, and are most speciose in temperate Asia where false smut fungi diversity is also great (Chlebicki 2006). Researchers sampling for molecular phylogenies of these plant groups should keep an eye out for associated false smut fungi, whose diversity is likely also understudied.

A co-evolutionary study of false smuts and their plant hosts will be necessary to settle the taxonomic questions raised here, and to understand the evolutionary history of both lineages. This would be a complex undertaking, since it will require careful sampling of both the plant hosts and species of *Bauerago*, *Liroa*, *Melanospichium*, *Microbotryum*, *Sphacelotheca*, *Zundeliomyces* and other members of Microbotryales (Chlebicki 2006; Kemler *et al.* 2006, 2009). In conclusion, our findings show that it is still possible to discover new and even fairly conspicuous organisms in urban environments and points to the importance of maintaining green spaces in densely populated areas for biodiversity research and conservation.

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Appendix 1. A survey of the literature including morphological or molecular data citing occurrences of false smut fungi *Liroo*, *Microbotryum*, *Sphocelotheco*, *Zundeliomyces* (Pucciniomycatina), *Entyloma*, *Melonopsichium* and *Thecophoro* (Ustilagionomycotina) parasitising Polygonaceae plant hosts. Currently accepted names for species of Polygonaceae and clades to which they belong (tribes) are also shown. N/A denotes not available.

Spp. No. (50 total)	Fungi	Polygonaceae clade	Polygonaceae host species (currently accepted name)	Synonym used in publication	Publication	Collection location (fungus)
1.	*Entylama palygani-amphibii* Săvul.	Persicarieae	*Persicario amphibio* (L.) Delarbre	*Palygonum amphibium* L.	Klenke & Schaller 2015; but see Vánky & Oberwinkler 1994	Italy
1.	*Liraa emadensis* (Berk.) Cif.	Persicarieae	*Persicaria chinensis* (L.) H.Grass	*Palygonum chinense* L.	Kemler et al. 2006; Piepenbring 2002	China, India, Indanesia, Nepal, Philippines, Sri Lanka, Taiwan
1.	*Melonapsichium austroamericanum* (Speg.) Beck	Persicarieae	*Persicaria punctata* (Elliatt) Small	*Palyganum punctatum* Elliatt	Vánky 2013	Argentina
2.	*Melanapsichium pennsylvonicum* Hirschh.	Persicarieae	*Persicorio pensylvanica* (L.) M.Gómez	*Palyganum pennsylvonicum* L.	Vánky 2013	North America
1.	*Micrabatryum ahmadionum* (Syd.) Vánky	Persicarieae	*Kaenigia rumicifalia* (Rayle ex Bab.) TM.Schust & Reveal	*Palyganum rumicifalium* Rayle ex Bab.	Vánky 1998	India
2.	*Micrabatryum anamalum* (J.Kunze ex G.Winter) Vánky	Palyganeae	*Fallapia baldschuanica* (Regel) Halub	*Fallapia oubertii* (L.Henry) Halub	Kemler et al. 2006	Hungary (cultivated)
	Micrabotryum onamalum (J.Kunze ex G.Winter) Vánky	Polyganeae	*Fallopia convalvulus* (L.) Á.Löve		Kemler et al. 2009	Germany
	Micrabotryum anamolum (J.Kunze ex G.Winter) Vánky	Palyganeae	*Fallapia dumetarum* (L.) Halub		Kemler et al. 2009	Germany
	Microbatryum anamolum (J.Kunze ex G.Winter) Vánky	Palyganeae	*Fallapia scandens* (L.) Halub	*Polyganum scandens* L.	Fischer 1953	North America
3.	*Micrabatryum oviculare* (Lira) Vánky	Palygoneae	*Palygonum aviculare* L.		Vánky 1998	Finland
	Microbatryum aviculare (Lira) Vánky	Palyganeae	*Palyganum axyspermum* subsp. *raii* (Bab.) D.A.Webb & Chater	*Polygonum raii* Bab.	Vánky 1994	N/A
4.	*Micrabatryum bistartorum* (DC.) Vánky	Persicarieae	*Bistarto bistortaides* (Pursh) Small	*Palyganum bistartoides* Pursh	Vánky 2013	N/A
	Micrabatryum bistartorum (DC.) Vánky	Persicarieae	*Bistorta comea* (K.Koch) Kom. ex Tzvelev	*Polyganum carneum* K.Kach	Vánky 1998	N/A
	Microbotryum bistortarum (DC.) Vánky	Persicarieae	*Bistorta milletii* (H. Lév.) H. Lév.	*Polygonum taipaishanense* H.W.Kung	Vánky 2013	N/A
	Microbotryum bistortarum (DC.) Vánky	Persicarieae	*Bistorta officinalis* (L.) Delarbre	*Polygonum bistorta* L.	Kemler et al. 2009	Switzerland
	Microbatryum bistartorum (DC.) Vánky	Persicarieae	*Bistarto vivipara* (L.) Delarbre	*Palyganum viviporum* L.	Kemler et al. 2006	Germany, Italy, Mongolia

Spp. No. (50 total)	Fungi	Polygonaceae clade	Polygonaceae host species (currently accepted name)	Synonym used in publication	Publication	Collection location (fungus)
5.	*Microbotryum bosniocum* (G.Beck) Vánky	Persicarieae	*Aconogonon ochreotum* var. *loxmonnii* (Lepech.) Tzvelev [likely *Koenigia*]	*Polygonum loxmonnii* Lepech.	Vánky 1998	N/A
	Microbotryum bosniocum (G.Beck) Vánky	Persicarieae	*Koenigia alpina* (All.) T.M.Schust. & Reveal	*Polygonum alpinum* All.	Kemler et al. 2006	Italy
	Microbotryum bosniocum (G.Beck) Vánky	Persicarieae	*Koenigia coriorio* (Grig.) T.M.Schust. & Reveal	*Polygonum buchoricum* Grig., *Polygonum coriorium* Grig.	Vánky 1998	N/A
	Microbotryum bosniocum (G.Beck) Vánky	Persicarieae	*Koenigia davisioe* (W.H.Brewer ex A.Gray) T.M.Schust. & Reveal	*Polygonum newberryi* Small	Vánky 1998	North America
	Microbotryum bosniocum (G.Beck) Vánky	Persicarieae	*Koenigia songorica* (Schrenk) T.M.Schust. & Reveal	*Polygonum songoricum* Schrenk	Vánky 1998	N/A
	Microbotryum bosniacum (G.Beck) Vánky	Persicarieae	*Koenigia tripterocarpa* (A.Gray) T.M.Schust. & Reveal	*Polygonum tripterocarpum* A.Gray	Vánky 2013	N/A
	Microbotryum bosniacum (G.Beck) Vánky	Persicarieae	*Persicaria punctata* (Elliott) Small	*Polygonum punctatum* Elliott	Vánky 2013	N/A
6.	*Microbotryum cilinode* (Savile) Vánky	Polygoneae	*Follopio cilinodis* (Michx.) Holub	*Bilderdykio cilinodis* (Michx.) Greene, *Polygonum cilinode* Michx.	Vánky 1998	North America
7.	*Microbotryum cordoe* (Liro) G.Deml & Prillinger	Persicarieae	*Koenigio componuloto* (Hook.f.) T.M.Schust & Reveal	*Polygonum componulotum* Hook.f.	Vánky 2013	N/A
	Microbotryum cordoe (Liro) G.Deml & Prillinger	Persicarieae	*Persicorio bungeono* (Turcz.) Nakai	*Polygonum bungeonum* Turcz.	Vánky 2013	China
	Microbotryum cordoe (Liro) G.Deml & Prillinger	Persicarieae	*Persicorio coespitoso* (Blume) Nakai	*Polygonum coespitosum* Blume	Vánky 2013	N/A
	Microbotryum cordoe (Liro) G.Deml & Prillinger	Persicarieae	*Persicorio folioso* (H.Lindb.) Kitag.	*Polygonum foliosum* H.Lindb.	Vánky 1994	Finland
	Microbotryum cordae (Liro) G.Deml & Prillinger	Persicarieae	*Persicaria hydropiper* (L.) Spach	*Polygonum hydropiper* L.	Kemler et al. 2006	Germany
	Microbotryum cordae (Liro) G.Deml & Prillinger	Persicarieae	*Persicaria hydropiperoides* (Michx.) Small	*Polygonum hydropiperoides* Michx.	Vánky & Oberwinkler 1994	N/A
	Microbotryum cordoe (Liro) G.Deml & Prillinger	Persicarieae	*Persicorio moculoso* A.Gray	*Polygonum persicorio* L.	Vánky & Oberwinkler 1994	Germany
	Microbotryum cordoe (Liro) G.Deml & Prillinger	Persicarieae	*Persicorio minor* (Huds.) Opiz	*Polygonum minus* Huds.	Vánky & Oberwinkler 1994	Finland
	Microbotryum cordoe (Liro) G.Deml & Prillinger	Persicarieae	*Persicario mitis* (Schrank) Holub	*Polygonum mite* Schrank	Vánky & Oberwinkler 1994	Italy

Spp. No. (50 total)	Fungi	Polygonaceae clade	Polygonaceae host species (currently accepted name)	Synonym used in publication	Publication	Collection location (fungus)
	Microbotryum cordae (Liro) G.Deml & Prillinger	Persicarieae	*Persicoria posumbu* (Buch.-Ham. ex D.Don) H.Gross	*Palyganum pasumbu* Buch.-Ham. ex D.Don	Vánky 2013	N/A
	Microbotryum cardae (Liro) G.Deml & Prillinger	Persicarieae	*Persicaria punctata* (Elliott) Small	*Palyganum punctatum* Elliott	Vánky & Oberwinkler 1994	N/A
	Micrabatryum cardae (Liro) G.Deml & Prillinger	Persicarieae	*Persicaria raseaviridis* Kitag.	*Palyganum raseaviride* (Kitag.) S.X.Li & Y.L.Chang	Vánky 2013	N/A
	Micrabatryum cardae (Liro) G.Deml & Prillinger	Persicarieae	*Persicaria viscasa* (Buch.-Ham. ex D.Don) H.Gross ex Nakai	*Polyganum viscasum* Buch.-Ham. ex D. Don	Vánky 2013	N/A
8.	*Microbotryum caranotum* (Liro) Vánky	Rumiceae	*Rumex britannica* L.		Vánky 1998	North America
9.	*Micrabatryum dehiscens* (L.Ling) Vánky	Persicarieae	*Bistorto officinalis* (L.) Delarbre	*Palyganum nitens* (Fisch. & C.A.Mey.) Petrav ex Kom.	Chlebicki 2006	Kazakhstan
	Micrabatryum dehiscens (L.Ling) Vánky	Persicarieae	*Bistarta vivipara* (L.) Delarbre	*Palygonum viviparum* L.	Vánky 1998	N/A
	Microbotryum dehiscens (L.Ling) Vánky	Persicarieae	*Persicaria amplexicaulis* (D.Don) Ronse Decr. [misidentified *Bistorta sinomontana* (Sam.) Miyam.?]	*Polygonum amplexicaule* D.Don	Vánky 1998	India
10.	*Microbotryum dumosum* (Vánky & Oberw.) Vánky	Rumiceae	*Rumex dumosus* A.Cunn. ex Meisn.		Vánky 1998	Australia
	Microbotryum dumosum (Vánky & Oberw.) Vánky	Rumiceae	*Rumex obtusifolius* L.		Vánky & Shivas 2008	Australia
	Micrabotryum dumasum (Vánky & Oberw.) Vánky	Rumiceae	*Rumex pulcher* L.		Vánky & Shivas 2008	Australia
	Micrabatryum dumasum (Vánky & Oberw.) Vánky	Rumiceae	*Rumex tenax* Rch.f.		Vánky & Shivas 2008	Australia
11.	*Microbatryum filamenticolo* (L.Ling) Vánky	Persicarieae	*Persicaria japanica* (Meisn.) Nakai	*Palyganum japanicum* Meisn.	Vánky 1998	China
12.	*Microbatryum gaeppertianum* (J.Schraet.) Vánky	Rumiceae	*Rumex ocetaso* L.		Vánky 1998	Poland
	Microbatryum gaeppertianum (J.Schraet.) Vánky	Rumiceae	*Rumex alpestris* Jacq.		Vánky 1998	N/A
	Microbatryum goeppertianum (J.Schraet.) Vánky	Rumiceae	*Rumex scutatus* L.		Vánky 1998	N/A
	Microbotryum goeppertianum (J.Schroet.) Vánky	Rumiceae	*Rumex thyrsiflorus* Fingerh.		Vánky 1998	N/A
13.	*Microbotryum himalense* (Kakish & Y.Ono)	Persicarieae	*Bistorta officinalis* (L.) Delarbre	*Polygonum bistorta* L.	Vánky 1998	Nepal
	Microbatryum himalense (Kakish & Y.Ono)	Persicarieae	*Bistarta suffulta* (Maxim.) Greene ex H. Gross	*Palygonum suffultaum* Maxim.	Vánky 2013	N/A

Spp. No. (50 total)	Fungi	Polygonaceae clade	Polygonaceae host species (currently accepted name)	Synonym used in publication	Publication	Collection location (fungus)
14.	*Microbotruym koenigioe* (Rostr.) Vánky	Persicarieae	*Koenigio islondico* L.		Vánky 1998	Greenland
	Microbotruym koenigioe (Rostr.) Vánky	Persicarieae	*Koenigio piloso* Maxim.		Vánky 2013	N/A
1S.	*Microbotryum kuehneonum* (R.Wolff) Vánky	Rumiceae	*Rumex ocetoso* L.		Ainsworth & Sampson 19S0	England
	Microbotryum kuehneonum (R.Wolff) Vánky	Rumiceae	*Rumex ocetosello* L.		Almaraz et al. 2002; Vánky 1998	Germany, North America, Spain
	Microbotryum kuehneonum (R.Wolff) Vánky	Rumiceae	*Rumex olpestris* Jacq.	*Rumex orifolius* All.	Vánky 1998	N/A
	Microbotryum kuehneonum (R.Wolff) Vánky	Rumiceae	*Rumex crispus* L.		Ainsworth & Sampson 1950	England
	Microbotryum kuehneonum (R.Wolff) Vánky	Rumiceae	*Rumex hostotulus* Baldwin		Vánky 2013	N/A
	Microbotryum kuehneanum (R.Wolff) Vánky	Rumiceae	*Rumex tuberosus* L.		Vánky 2013	N/A
16.	*Microbotryum longisetum* (Vánky & Oberw.)Vánky	Persicarieae	*Persicaria longiseta* (Bruijn) Kitag.	*Polygonum longisetum* Bruijn	Vánky 1998	Taiwan
17.	*Microbotryum morginole* (DC.) Vánky	Persicarieae	*Bistorto officinolis* (L.) Delarbre	*Polygonum bistorto* L., *Polygonum nitens* (Fisch. & C.A.Mey.) Petrov ex Kom.	Kemler et al. 2009; Vánky 1998; Vánky 2013	France, Poland, Switzerland
	Microbotryum morginole (DC.) Vánky	Persicarieae	*Bistorto bistortoides* (Pursh) Small	*Polygonum bistortoides* Pursh	Vánky 2013	N/A
	Microbotryum morginole (DC.) Vánky	Persicarieae	*Bistorto corneo* (K.Koch) Kom. ex Tzvelev	*Polygonum comeum* K.Koch	Vánky 2013	N/A
	Microbotryum morginole (DC.) Vánky	Persicarieae	*Bistorto elliptico* (Willd. ex Spreng.) D.F. Murray & Elven	*Polygonum ellipticum* Willd. ex Spreng.	Vánky 2013	N/A
18.	*Microbotryum moelleri* (Bref.) Vánky	Persicarieae	*Persicoria hispida* (Kunth) M.Gómez	*Polygonum hispidum* Kunth	Vánky 2013	Brazil
19.	*Microbotryum nepolense* (Liro) Vánky	Persicarieae	*Persicoria nepalensis* (Meisn.) H.Gross	*Polygonum olotum* Buch.-Ham. ex D.Don	Kemler et al. 2006; Vánky 1998	India, China
20.	*Microbotryum ocreorum* (Berk.) Vánky	Persicarieae	*Koenigio componuloto* (Hook.f.) T.M.Schust. & Reveal	*Polygonum componulotum* Hook.f.	Vánky 1998	China
21.	*Microbotryum porlotorei* (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex ocetosello* L.		Fischer 1953	North America
	Microbotryum porlotorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex olpinus* L.		Vánky 1998	N/A
	Microbotryum porlatorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex oltissimus* Alph. Wood		Vánky 1998	N/A

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	Microbotryum porlotorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex britonnico* L.		Fischer 1953	North America
	Microbotryum porlotorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex crispus* L.		Vánky 1998	N/A
	Microbotryum porlotorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex dentotus* L.		Vánky 1998	N/A
	Microbotryum porlotorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex hostotulus* 8aldwin		Fischer 1953	North America
	Microbotryum porlotorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex longifolius* DC.		Vánky 1998	Norway
	Microbotryum porlotorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex moritimus* L.		Kemler et al. 2006	Germany
	Microbotryum parlatorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex mexicanus* Meisn.		Vánky 1998	N/A
	Microbotryum parlatorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex obtusifolius* L.		Vánky & Shivas 2008	Australia
	Microbotryum porlotorei (A.A.Fisch.Waldh.) Vánky	Rumiceae	*Rumex polustris* Sm.		Vánky 1998	N/A
22.	*Microbotryum poucireticulotum* Vánky	Persicarieae	*Persicorio orientolis* (L.) Spach	*Polygonum orientole* L.	Vánky 2013	India
23.	*Microbotryum picoceum* (Lagerh. & Liro) Vánky	Persicarieae	*Koenigio forrestii* (Diels) Měsíček & Soják		Vánky 1998	N/A
	Microbotryum picoceum (Lagerh. & Liro) Vánky	Persicarieae	*Koenigio islondico* L.		Vánky 1998	Norway
24.	*Microbotryum piperi* (G.P.Clinton) Vánky	Persicarieae	*Koenigia alpina* (All.) T.M.Schust. & Reveal	*Polygonum alpinum* All., *Polygonum undulatum* P.J. Bergius	Vánky1998; Chlebicki 2006	Italy, Kazakhstan
	Microbotryum piperi (G.P.Clinton) Vánky	Persicarieae	*Koenigio dovisioe* (W.H.Brewer ex A.Gray) T.M.Schust. & Reveal	*Polygonum dovisioe* W.H.8rewer ex A.Gray	Vánky 1998	North America
	Microbotryum piperi (G.P.Clinton) Vánky	Persicarieae	*Koenigio phytoloccifolio* (Meisn. ex Small) T.M.Schust. & Reveal	*Polygonum phytoloccoefolium* Meisn.	Vánky 1998	North America
	Microbotryum piperi (G.P.Clinton) Vánky	Persicarieae	*Koenigio rumicifolio* (Royle ex Bab.) T.M.Schust. & Reveal	*Polygonum rumicifolium* Royle ex 8ab.	Vánky 2013	N/A
	Microbotryum piperi (G.P.Clinton) Vánky	Persicarieae	*Koenigio songorico* (Schrenk) T.M.Schust. & Reveal	*Polygonum songoricum* Schrenk	Vánky 1998	N/A
	Microbotryum piperi (G.P.Clinton) Vánky	Persicarieae	*Koenigio tripterocorpo* (A.Gray) T.M.Schust. & Reveal	*Polygonum tripterocorpum* A.Gray	Vánky 2013	N/A
25.	*Microbotryum polygoni-oloti* (Thirum. & M.S.Pavgi) Vánky	Persicarieae	*Persicorio nepolensis* (Meisn.) H.Gross	*Polygonum olotum* (8uch.-Ham. ex D.Don	Vánky 1998	India

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26.	*Microbotryum prostrotum* (Vánky & Oberw.) Vánky	Persicarieae	*Persicorio prostroto* (R.Br.) Soják	*Polygonum prostrotum* R.Br.	Vánky 1998	Australia
	Microbotryum prostrotum (Vánky & Oberw.) Vánky	Persicarieae	*Persicorio subsessilis* (R.Br.) K.L.Wilson	*Polygonum subsessile* R.Br.	Vánky 2013	N/A
27.	*Microbotryum pustulotum* (DC.) R. Bauer & Oberw.	Persicarieae	*Bistorto officinolis* (L.) Delarbre	*Polygonum bistorto* L., *Polygonum nitens* (Fisch. & C.A.Mey.) Petrov ex Kom.	Kemler et al. 2006; Vánky 2013	France, Germany, Switzerland
	Microbotryum pustulotum (DC.) R. Bauer & Oberw.	Persicarieae	*Bistorto corneo* (K.Koch) Kom. ex Tzvelev	*Polygonum corneum* K.Koch	Vánky 2013	N/A
	Microbotryum pustulotum (DC.) R. Bauer & Oberw.	Persicarieae	*Bistorto elliptico* (Willd. ex Spreng.) D.F. Murray & Elven	*Polygonum ellipticum* Willd. ex Spreng.	Vánky 2013	N/A
	Microbotryum pustulotum (DC.) R. Bauer & Oberw.	Persicarieae	*Bistorto viviporo* (L.) Delarbre	*Polygonum viviporum* L.	Vánky 1998	Norway
28.	*Microbotryum rodions* (Vánky & Oberw.) Vánky	Persicarieae	*Persicorio coreyi* (Olney) Greene	*Polygonum coreyi* Olney	Vánky 1998	North America
29.	*Microbotryum reticulotum* (Liro) R.Bauer & Oberw.	Persicarieae	*Persicorio omphibio* (L.) Delarbre	*Polygonum omphibium* L., *Polygonum coccineum* Muhl. ex Willd.	Fischer 1953	North America
	Microbotryum reticulatum (Liro) R.Bauer & Oberw.	Persicarieae	*Persicaria longiseta* (Bruijn) Kitag.	*Polygonum blumei* Meisn. ex Miq.	Vánky 2013	N/A
	Microbotryum reticulatum (Liro) R.Bauer & Oberw.	Persicarieae	*Persicaria careyi* (Olney) Greene	*Polygonum careyi* Olney	Fischer 1953	North America
	Microbotryum reticulotum (Liro) R.Bauer & Oberw.	Persicarieae	*Persicorio lopothifolio* (L.) Delarbre	*Polygonum lopothifolium* L.	Kemler et al. 2006	Austria, Bulgaria, Switzerland
	Microbotryum reticulotum (Liro) R.Bauer & Oberw.	Persicarieae	*Persicorio pensylvonico* (L.) M.Gómez	*Polygonum pennsylvonicum* L.	Fischer 1953	North America
	Microbotryum reticulotum (Liro) R.Bauer & Oberw.	Persicarieae	*Persicorio senegolensis* (Meisn.) Soják	*Polygonum senegolense* Meisn.	Vánky 2013	Rwanda
	Microbotryum reticulotum (Liro) R.Bauer & Oberw.	Persicarieae	*Persicorio sogittoto* (L.) H.Gross	*Polygonum sogittotum* L.	Fischer 1953	North America
	Microbotryum reticulotum (Liro) R.Bauer & Oberw.	Polygoneae	*Polygonum oviculore* L.		Fischer 1953	North America
30.	*Microbotryum rhei* (Zundel) Vánky	Rumiceae	*Rheum moximowiczii* Losinsk.		Vánky 1998	Kazakhstan
	Microbotryum rhei (Zundel) Vánky	Rumiceae	*Rheum rhabarbarum* L.	*Rheum undulatum* L., *Rheum franzenbachii* Münter	Vánky 1998	N/A
	Microbotryum rhei (Zundel) Vánky	Rumiceae	*Rheum tataricum* L.f.		Vánky 2013	N/A
	Microbotryum rhei (Zundel) Vánky	Rumiceae	*Rheum wittrockii* C.E. Lundstr.		Vánky 1998	N/A

Spp. No. (50 total)	Fungi	Polygonaceae clade	Polygonaceae host species (currently accepted name)	Synonym used in publication	Publication	Collection location (fungus)
31.	*Microbotryum shostense* (Zundel) Vánky	Polygoneae	*Polygonum shostense* W.H.Brewer	*Polygonum shostense* W.H.Brewer	Kemler et al. 2006	North America
32.	*Microbotryum stewortii* (Zundel) Vánky	Rumiceae	*Rheum webbionum* Royle		Vánky 1998	India
33.	*Microbotryum stygium* (Liro) Vánky	Rumiceae	*Rumex ocetoso* L.		Kemler et al. 2006	Germany
	Microbotryum stygium (Liro) Vánky	Rumiceae	*Rumex olpestris* Jacq.	*Rumex orifolius* All.	Vánky 1998	N/A
	Microbotryum stygium (Liro) Vánky	Rumiceae	*Rumex scutotus* L.		Vánky 1998	N/A
	Microbotryum stygium (Liro) Vánky	Rumiceae	*Rumex thyrsiflorus* Fingerh.		Vánky 1998	N/A
34.	*Microbotryum tenuisporum* (Cif.) Vánky	Persicarieae	*Persicorio ocuminoto* (Kunth) M.Gómez	*Polygonum ocuminotum* Kunth	Vánky 1998	N/A
	Microbotryum tenuisporum (Cif.) Vánky	Persicarieae	*Persicorio borboto* (L.) H.Hara	*Polygonum borbotum*	Vánky 1998	N/A
	Microbotryum tenuisporum (Cif.) Vánky	Persicarieae	*Persicorio globro* (Willd.) M.Gómez	*Polygonum globrum* Willd.	Kemler et al. 2006	India
	Microbotryum tenuisporum (Cif.) Vánky	Persicarieae	*Persicaria hydropiper* (L.) Spach	*Persicaria hydropiper* (L.) Spach	Vánky & Shivas 2008	Australia
	Microbotryum tenuisporum (Cif.) Vánky	Persicarieae	*Persicaria hydropiperoides* (Michx.) Small	*Polygonum hydropiperoides* Michx.	Vánky 2013	N/A
	Microbotryum tenuisporum (Cif.) Vánky	Persicarieae	*Persicorio lopathifolia* (L.) Delarbre	*Polygonum lopothifolium* L., *Polygonum lonigerum* R. Br.	Vánky 2013	N/A
	Microbotryum tenuisporum (Cif.) Vánky	Persicarieae	*Persicorio punctoto* (Elliott) Small	*Polygonum punctotum* Elliott	Piepenbring 1996; Vánky & Shivas 2008	Argentina, Costa Rica
35.	*Microbotryum tovoroe* (Saville) Vánky	Persicarieae	*Persicorio virginiono* (L.) Gaertn.	*Polygonum virginionum* L.	Vánky 1998	North America
36.	*Microbotryum tuberculiforme* (Syd. & Syd.) Vánky	Persicarieae	*Persicario chinensis* (L.) H.Gross	*Polygonum chinense* L.	Vánky 2013	N/A
	Microbotryum tuberculiforme (Syd. & Syd.) Vánky	Persicarieae	*Persicorio runcinoto* (Buch.-Ham. ex D.Don) H.Gross	*Polygonum runcinotum* Buch.-Hamilt. ex D.Don	Kemler et al. 2006	Taiwan
37.	*Microbotryum tumeforme* (L.Ling) Vánky	Persicarieae	*Persicorio chinensis* (L.) H.Gross	*Polygonum chinense* L.	Vánky 1998	India
	Microbotryum tumeforme (L.Ling) Vánky	Rumiceae	*Rumex crispus* L.	*Rumex mogellonicus* Campd.	Vánky 2013	N/A
38.	*Microbotryum vinosum* (Tul. & C.Tul.) Denchev	Rumiceae	*Oxyrio digyno* (L.) Hill	*Oxyrio digyno* (L.) Hill	Almaraz et al. 2002	N/A
39.	*Microbotryum wormingii* (Rostr.) Vánky	Rumiceae	*Rumex oquoticus* L.		Vánky 1998	N/A
	Microbotryum wormingii (Rostr.) Vánky	Rumiceae	*Rumex orcticus* Trautv.		Vánky 2013	N/A
	Microbotryum wormingii (Rostr.) Vánky	Rumiceae	*Rumex crispus* L.		Vánky 1998	Norway
	Microbotryum wormingii (Rostr.) Vánky	Rumiceae	*Rumex longifolius* DC.		Vánky 1998	N/A

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1.	*Sphacelatheca fagapyri* Syd., P.Syd. & E.J.Butler	Fagapyreae	*Fagapyrum esculentum* Maench		Saccarda 1912	India
2.	*Sphacelatheca hydropiperis* (Schumach.) deBary	Persicarieae	*Kaenigia nummularifalia* (Meisn.) Měsíček & Saják	*Palyganum nummularifalium* Meisn.	Vánky & Oberwinkler 1994	N/A
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria acuminata* (Kunth) M.Gómez	*Palyganum acuminatum* Kunth	Piepenbring 1996	Casta Rica
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria decipiens* (R.Br.) K.L.Wilson	*Palyganum serrulatum* Lag.	Kakishima & Ona 1993; http://mycapartal.org	India, Pakistan
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria filifarmis* (Thunb.) Nakai	*Palyganum filifarme* Thunb.	Vánky & Oberwinkler 1994	Japan
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria hispida* (Kunth) M.Gámez	*Palyganum hispidum* Kunth	Vánky & Oberwinkler 1994	N/A
	Sphacelotheca hydropiperis (Schumach.) deBary [as *Sphacelotheca koordersiana* (Bref.) Zundel]	Persicarieae	*Persicaria hydropiper* (L.) Spach	*Polygonum hydropiper* L.	Piepenbring 1996; Vánky 2002	Costa Rica
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria maculasa* A.Gray	*Palyganum persicaria* L.	Vánky 1994	N/A
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria minar* (Huds.) Opiz	*Palyganum minus* Huds.	Vánky & Oberwinkler 1994	N/A
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria mitis* (Schrank) Hałub	*Palyganum mite* Schrank	Vánky & Oberwinkler 1994	N/A
	Sphacelotheca hydropiperis (Schumach.) deBary [as *Sphacelotheca borealis* (G.P.Clinton) Schellenb.]	Persicarieae	*Persicaria posumbu* (Buch.-Ham. ex D.Don) H.Gross	*Polygonum posumbu* Buch.-Ham. ex D.Don	http://mycoportal.org	China
	Sphacelatheca hydropiperis (Schumach.) deBary	Persicarieae	*Persicaria punctata* (Elliatt) Small	*Palyganum punctatum* Elliatt	Piepenbring 1996	Casta Rica
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria sagittata* (L.) H.Grass	*Palygonum sagittatum* L.	Vánky & Oberwinkler 1994	North America
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria sagittifalia* (H.Lév. & Vaniat) H.Grass	*Palyganum sagittifalium* H.Lév. & Vaniat	Vánky & Oberwinkler 1994	N/A
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria strindbergii* (J.Schust.) Galassa	*Palyganum strindbergii* J.Schust.	Vánky & Oberwinkler 1994	N/A
	Sphacelatheca hydrapiperis (Schumach.) deBary	Persicarieae	*Persicaria thunbergii* (Siebald & Zucc.) H.Grass	*Polyganum thunbergii* Siebald & Zucc.	Vánky & Oberwinkler 1994	N/A
3.	*Sphacelatheca kaardersiana* (Bref.) Zundel	Persicarieae	*Persicaria acuminata* (Kunth) M.Gómez	*Palyganum acuminatum* Kunth	Vánky & Oberwinkler 1994	Casta Rica
	Sphacelatheca kaardersiana (Bref.) Zundel	Persicarieae	*Persicaria barbata* (L.) H.Hara	*Palyganum barbatum* L.	Vánky & Oberwinkler 1994	Java

Spp. No. (50 total)	Fungi	Polygonaceae clade	Polygonaceae host species (currently accepted name)	Synonym used in publication	Publication	Collection location (fungus)
	Sphacelatheca kaardersiana (Bref.) Zundel	Persicarieae	*Persicaria decipiens* (R.Br.) K.L.Wilson	*Palyganum salicifalium* Brauss. ex Willd.	Vánky & Oberwinkler 1994; McKenzie & Vánky 2001	New Zealand
4.	*Sphacelotheca palygani-serrulati* Maire	Persicarieae	*Persicaria barbata* (L.) H.Hara	*Palyganum barbatum* L.	Vánky & Oberwinkler 1994	Rwanda
	Sphacelatheca palygani-serrulati Maire	Persicarieae	*Persicaria decipiens* (R.Br.) K.L.Wilsan	*Palyganum serrulatum* Lag.	Maire 1917; 2002; Kemler et al. 2009	Algeria, Greece, Spain
	Sphacelatheca palygani-serrulati Maire	Persicarieae	*Persicaria decipiens* (R.Br.) K.L.Wilsan		Vánky & Shivas 2008; Piątek et al. 2012	Australia, Cameraan
	Sphacelotheca polygoni-serrulati Maire	Persicarieae	*Persicaria maculosa* Gray	*Polygonum persicaria* L.	Vánky 1994	Madeira
	Sphacelotheca polygoni-serrulati Maire	Persicarieae	*Persicaria pulchra* (Blume) Soják	*Persicaria pulchra* (Blume) Soják	Piątek et al. 2012	Zambia
	Sphacelotheca polygoni-serrulati Maire	Persicarieae	*Persicaria setosula* (A.Rich.) K.L.Wilson	*Polygonum setosulum* A.Rich.	Vánky 1994	N/A
5.	*Sphacelotheca serrulati-magna* Vánky & Oberw.	Persicarieae	*Persicaria decipiens* (R.Br.) K.L.Wilson	*Polygonum salicifolium* Brouss. ex Willd.	Vánky & Oberwinkler 1994	Greece
1.	*Thecaphora schwarzmaniana* Byzova	Rumiceae	*Rheum cordatum* Losinsk.		Vánky 2013	Kazakhstan
	Thecaphora schwarzmaniana Byzova	Rumiceae	*Rheum macrocarpum* Losinsk.	*Rheum lobatum* Litv. ex Losinsk.	Vánky 2013	N/A
	Thecaphora schwarzmaniana Byzova	Rumiceae	*Rheum palmatum* L.		Vánky 2013	N/A
	Thecaphara schwarzmaniana Byzava	Rumiceae	*Rheum ribes* L.		Vasighzadeh et al. 2014	Iran
1.	*Zundeliamyces palygani* Vánky	Persicarieae	*Kaenigia alpina* (All.) T.M.Schust. & Reveal	*Palyganum alpinum* All.	Vánky 1987	Kazakhstan

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Further additions to the lichen genus *Ramboldia* (Lecanoraceae) from Australia

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Introduction

The genus *Ramboldia* was first introduced by Kantvilas & Elix (1994) to accommodate five species of saxicolous, lignicolous or corticolous Australasian species of lecideoid crustose lichens. These authors (*loc. cit.*) noted the apparent close relationship of *Ramboldia* to the genus *Pyrrhospora* (sensu Hafellner 1993), in particular with respect to the structure of the ascus and the size and shape of the ascospores. The two genera differed primarily in the absence of anthraquinone pigments in the former (Kantvilas & Elix 1994; Elix & Kantvilas 2005). Subsequently further species were added to *Ramboldia*, not only from Australasia (Kalb 2001, 2004; Kantvilas & Elix 2007) but also from other parts of the world; for example, Thailand (Kalb *et al.* 2009), India (Upreti *et al.* 2009) and North America (Lendemer & Harris 2011). Whereas some represented discoveries of species new to science, others were examples of rather well-known species that were transferred from other genera; for example, *R. elabens* (Fr.) Kantvilas & Elix (Kantvilas & Elix 2007) and *R. insidiosa* (Th.Fr.) Hafellner (Hafellner & Türk 1995). A major advance in the understanding of the limits and relationships of the genus came with the study of Kalb *et al.* (2008) who, on the basis of DNA sequence data, demonstrated that *Pyrrhospora* was heterogeneous, and transferred most species ascribed to that genus to *Ramboldia*. Thus *Ramboldia* today includes species either with or without anthraquinones, all united essentially by having a crustose thallus with a unicellular, green photobiont, biatorine apothecia with a mostly internally unpigmented excipulum composed of radiating, branched and anastomosing prosoplectechymatous hyphae, eight-spored *Lecanora*-type asci with

Abstract

Two lichens new to science are described and illustrated: *Ramboldia atromarginata* Kantvilas is corticolous in wet sclerophyll forest in Victoria, and *R. greeniana* Kantvilas is a saxicolous species found chiefly in upland areas of Tasmania. The New Zealand endemic taxon, *Lecidea subsericea* Zahlbr., is found to be a synonym of *Ramboldia stuartii* (Hampe) Kantvilas & Elix.

Key words: anthraquinone pigments, biodiversity, lichenised ascomycetes, New Zealand, Tasmania, taxonomy, Victoria

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a masse axiale with parallel or diverging flanks that penetrates the tholus completely, simple or sparsely branched and anastomosing paraphyses, relatively small, hyaline, non-halonate, simple ascospores and filiform conidia (Kantvilas & Elix 2007; Elix 2009). The species may be saxicolous, lignicolous, corticolous or lichenicolous. Thallus chemistry is diverse and includes fatty acids, depsidones, depsides and xanthones (Kalb *et al.* 2008); some species, particularly the red-fruited taxa, may contain no substances, apart from the apothecial pigment, russulone. Today the genus is estimated to comprise 32 species (Mycobank website, January 2016), and is widely distributed in both hemispheres. Sixteen species are known from Australasia (McCarthy 2015). In this paper, two further red-fruited taxa are described and some collections from New Zealand are discussed.

Materials and methods

The study is based on collections of the author, housed in the Tasmanian Herbarium (HO) with duplicates distributed to other herbaria as stated. Hand-cut sections of the thallus and ascomata were mounted in water, 15% KOH (K), Lugols Iodine after pretreatment with K (KI), ammoniacal erythrosin and lactophenol cotton blue for examination by high-power light microscopy. Dimensions of asci and ascospores are based on at least 20 and 60 observations respectively. The latter are presented in the format: 5th percentile–*average*–95th percentile; outlying extreme values are given in parentheses. Routine chemical investigations were conducted using thin-layer chromatography following standard methods (Orange *et al.* 2001). The occurrence of russulone was established by Prof. J.A. Elix (Canberra).

Taxonomy

1. *Ramboldia atromarginata* Kantvilas sp. nov.

MycoBank no.: MB 816238

Ad aggregatum *Ramboldiam russulam* pertinens sed ab omnibus his speciebus margine apotheciae atro-fusco, interne rubro-brunneo, in KOH non-reagenti differt.

Type: **Australia, Victoria.** Errinundra National Park, Tea Tree Flat Picnic Area, 37°14'33"S 148°50'06"E, 880 m alt., on *Tasmannia* in wet forest, 27 October 2010, *G. Kantvilas 262/10, J.A. Elix & P.M. McCarthy* (holotype: HO 559266; isotype: MEL).

Thallus crustose, pale glaucous grey, continuous, smooth, relatively even and following the contours of the substratum, sometimes becoming minutely rimose-verruculose, not delimited by a prothallus, forming irregularly roundish thalli to c. 15 mm wide and 30–60 µm thick, in section ecorticate, or with a weakly defined cortex of interwoven, periclinal hyphae c. 2 µm thick. *Photobiont* a unicellular green alga with cells ± globose, 6–14 µm wide. *Apothecia* 0.3–1.2 mm wide, biatorine, roundish, scattered, sessile and basally constricted; disc rusty red-brown, matt, epruinose, persistently plane to slightly undulate; proper excipulum blackish, persistent, entire to crenulate, evident even in the oldest apothecia as a thin, dark rim, in section 50–80(–120) µm wide, dark red-brown, unchanged or intensifying in KOH, sometimes a little paler at the outer edge, continuous beneath the hypothecium (cupular) or almost so (annular), composed of radiating, branched and anastomosing hyphae 5–8 µm wide with narrow (c. 2 µm), often brown-pigmented lumina. *Hypothecium* 50–90 µm thick, pale yellowish or yellow-orange, colour intensifying in KOH. *Hymenium* 50–70 µm thick, coherent in water and KOH, inspersed with and overlain in the upper part by a layer *c.* 10 µm thick of minute red-brown crystals, K+ magenta and not dissolving; asci narrowly clavate, 35–45(–50) × 9–14 µm, approximating the *Lecanora*-type but with the flanks of the amyloid masse axiale usually widely divergent and the ocular chamber rather poorly developed; paraphyses 1.5–2 µm thick, sparsely branched, with occasional anastomoses in the lower part, with apices neither pigmented nor expanded. *Ascospores* hyaline, simple, fusiform, mostly with rather truncate apices, or oblong, rarely slightly dumb-bell-shaped, (8.5–)9–*11.4*–14(–15) × (2–)2.5–*3.0*–3.5 µm. *Pycnidia* not found. *Chemistry*: thallus containing no substances detectable by t.l.c.; apothecia containing russulone. (Fig. 1)

Etymology: The specific epithet refers to the diagnostic blackish brown margin of the apothecia.

Distribution and ecology: This new species is known only from the type collection, from the smooth bark of the shrub *Tasmannia* (Winteraceae) in the understorey of wet eucalypt forest. This is a relatively rich habitat for lichens and associated species included *Fuscidea australis* Kantvilas var. *australis*, *Japewiella pruinosula* (Müll.Arg.) Kantvilas, *Loxospora solenopsora* (Müll.Arg.)

Kantvilas, *Mycoblastus campbellianus* (Nyl.) Zahlbr., *Ochrolechia blandior* (Nyl.) Darb., *Phlyctis subuncinata* Stirt. and species of *Menegazzia*, *Usnea* and *Hypogymnia*.

Remarks: There are 18 species of *Ramboldia* that belong to the so-called *R. russula* (Ach.) Kalb *et al.* group, characterised by apothecia with red, K+ magenta anthraquinone pigments (Kalb *et al.* 2008). None display the very distinctive blackish brown apothecial margin that characterises *R. atromarginata*. The new species is characterised further by lacking any thalline secondary compounds: most species of the group contain fatty acids or other substances (Kalb *et al.* 2008; Elix 2009).

An enigmatic specimen from New Zealand (*Kantvilas* 353/10; HO), collected from a fallen canopy branch of *Nothofagus solandri* var. *cliffortioides*, deserves some discussion. Superficially this specimen is ± identical with the type specimen of *R. atromarginata* as described above, with orange-brown apothecia with a thin blackish brown margin, and concomitant apothecial anatomy. Yet apothecial sections consistently reveal at least some asci with narrowly ellipsoid, clearly 1-septate ascospores (7–10 × 3–4 µm), whereas other asci contain fusiform, simple ascospores, 8–11 × 2.5–4 µm. More collections from New Zealand are required to clarify this curious situation. If the 1-septate ascospores are consistently present, then this represents a significant modification of the anatomy of the genus as currently understood. Other species of *Ramboldia* frequently have pseudo-septate ascospores with plasma bridges that show up clearly when stained with, for example, lactophenol cotton blue, but the ascospores of the New Zealand collection seem to be truly septate. The asci and excipular anatomy of this specimen are consistent with *Ramboldia*.

2. *Ramboldia greeniana* Kantvilas sp. nov.

MycoBank No.: MB 816239

Ramboldiae laetae similis sed thallo minute papillato vel isidiato et habitu saxicola differt.

Type: **Australia, Tasmania.** Mersey Crag, 41°46'S 146°20'E, 1420 m altitude, on alpine dolerite boulders, 3 February 2010, *G. Kantvilas 71/10* (holotype: HO).

Thallus crustose, dull grey, grey-brown to olive-brown, frequently in part overgrown by blackish cyanobacteria, verruculose to papillate to ± isidiate, mostly rather

Figure 1. *Ramboldia atromarginata* (holotype) habit, showing biatorine apothecia with a red-brown disc and diagnostic blackish margin. Scale = 1 mm.

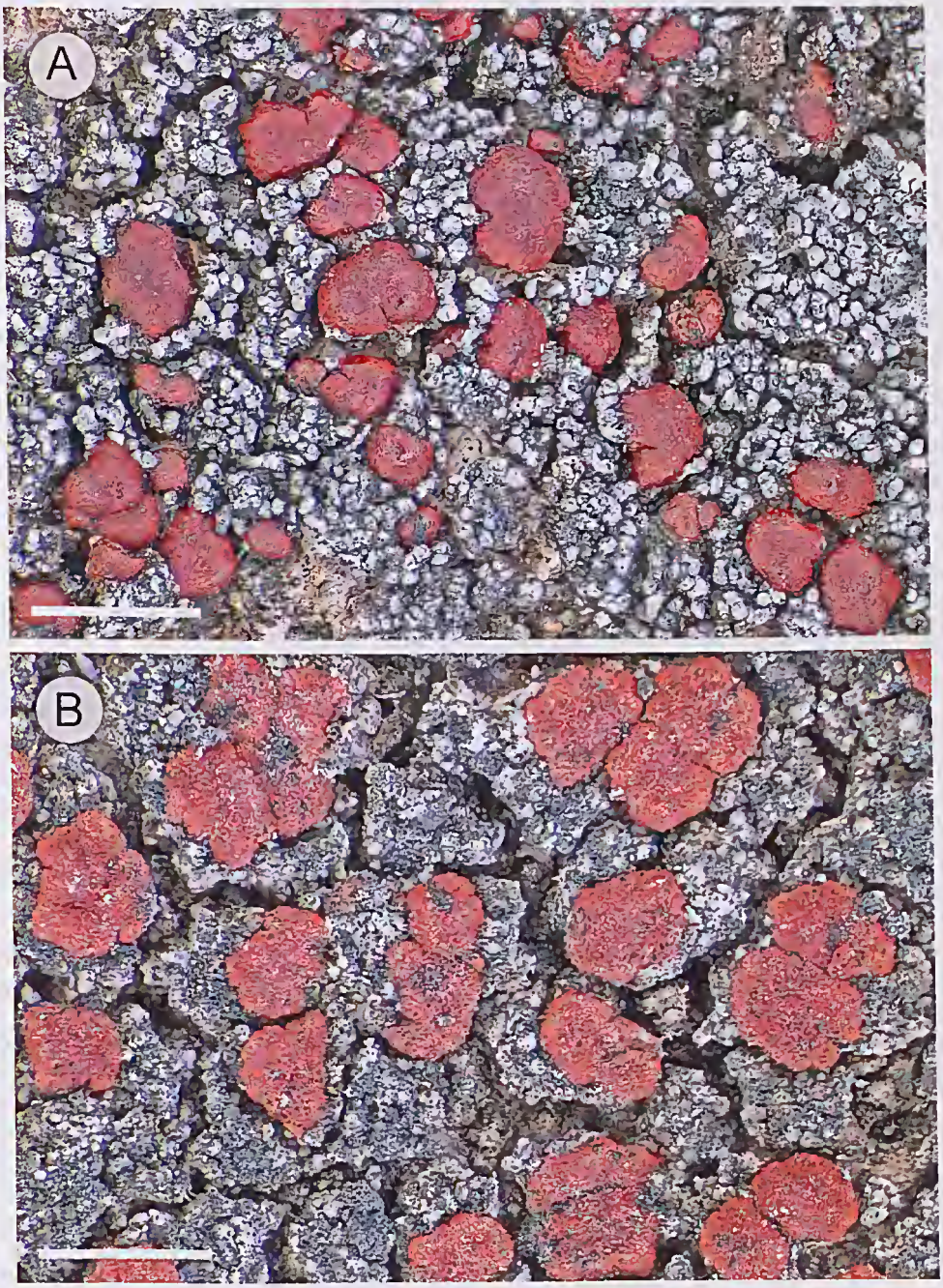
loosely attached to the substratum, not delimited by a prothallus, forming irregular, usually deeply cracked thalli to c. 100 mm wide and to 0.6(–1) mm thick, usually as islands surrounded by other crustose lichens, in section ± ecorticate; isidia when well developed rather knob-like, 0.06–0.08 mm wide, erect or decumbent, with pale grey tips, more frequently abraded or fractured and rather inapparent. *Photobiont* a unicellular green alga with cells ± globose, 5–12 µm wide. *Apothecia* 0.3–1 mm wide, biatorine, roundish or rather irregularly rhomboidal or lobed, scattered or clustered, sessile and basally constricted; disc bright scarlet red to brownish red, waxy, matt, epruinose, plane at first, soon convex; proper excipulum concolorous with the disc, entire, crenulate or flexuose, becoming excluded or inapparent in older apothecia, in section 40–120 µm wide, deflexed, colourless to pale yellow, densely inspersed with chains of minute orange crystals that turn magenta in KOH but do not dissolve, open beneath the hypothecium (annular), composed of radiating, branched and anastomosing hyphae 4–6 µm wide with thread-like lumina c. 1 µm wide. *Hypothecium* 40–60(–100) µm thick, pale yellowish, likewise inspersed. *Hymenium* 55–70 µm thick, usually highly coherent in water and KOH, pale yellowish to colourless, inspersed as in the excipulum and hypothecium with minute orange, K+ magenta crystals forming chains between the asci and paraphyses; asci narrowly clavate, 35–50 × 11–14 µm, approximating the *Lecanora*-type but with the flanks of the amyloid masse axiale usually widely divergent and the ocular chamber rather poorly developed; paraphyses 1.5–2.5 µm thick, rather robust, simple to sparsely branched and anastomosed, with apices neither pigmented nor expanded. *Ascospores* hyaline, simple, fusiform to ellipsoid, (7–)8–*9.7*–12(–14) × (2.5–)3–*3.5*–4(–4.5) µm. *Pycnidia* uncommon, immersed in the thallus surface and evident as minute black specks; conidia thread-like, curved, 20–30 × 0.5 µm. *Chemistry*: thallus containing no substances detectable by t.l.c.; russulone present in the apothecia (K+ magenta). (Figs 2, 3A–B, 4)

***Etymology*:** The specific epithet honours Sir Guy Green, AC, KBE, CVO, who, as Chairman of the Board of Trustees on the Tasmanian Museum and Art Gallery (2003–2015), was a stalwart champion of the natural sciences, particularly taxonomy.

Figure 2. *Ramboldia greeniana* (red apothecia) habitat on dolerite boulders, associated with numerous other crustose lichens.

***Distribution and ecology*:** *Ramboldia greeniana* is known only from Tasmania, where it has been recorded exclusively from Jurassic dolerite. Although most commonly collected from highland situations, it has a wide ecological range that extends from lowland dry eucalypt forest to the alpine summits of the highest peaks. It inhabits the largest boulders and outcrops (where its collection can pose a challenge), typically in very exposed aspects such as rock screes and boulder fields, where it is part of a diverse assemblage of saxicolous lichens, the most common of which include *R. petraeoides* (Nyl. ex C.Bab. & Mitt.) Kantvilas & Elix, *Hymenelia gyalectoidea*

Figure 3. *Ramboldia greeniana* habit. A: holotype, showing a well-developed, isidiate thallus. B: *Kantvilas 924/01*, with the isidia abraded, fractured and eroded. Scale = 1 mm.



Kantvilas, *Lecanora farinacea* Fée, *L. galactiniza* Nyl., *Menegazzia aeneofusca* (Müll.Arg.) R.Sant., *Pertusaria lophocarpa* Körb., *Tephromela atra* (Huds.) Hafellner, *Trapelia lilacea* Kantvilas & Elix, *Xanthoparmelia mougeotina* (Nyl.) D.J.Galloway, *X. stygiodes* (Nyl. ex Cromb.) O.Blanco *et al.*, and species of *Lecidea*, *Porpidia* and *Rhizocarpon*.

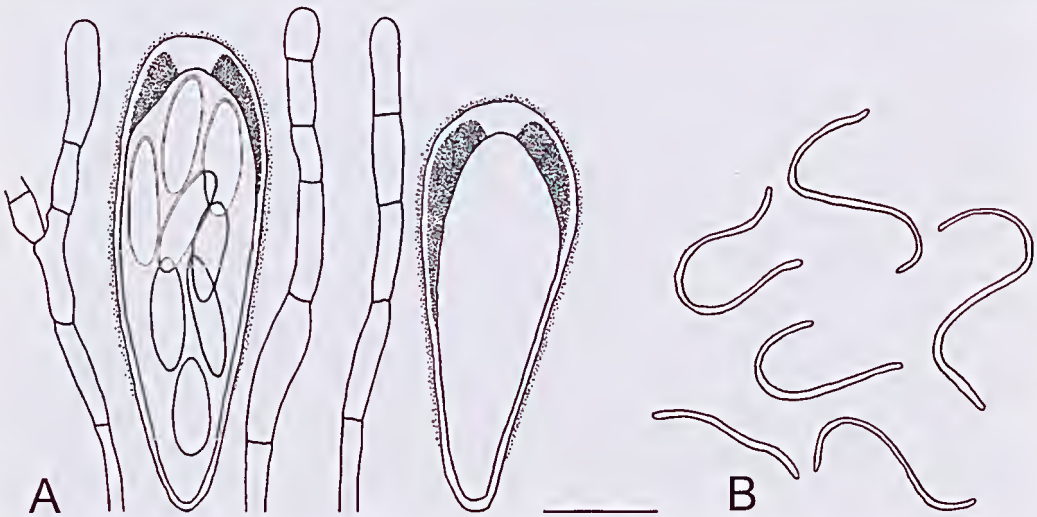
Remarks: *Ramboldia greeniana* is a conspicuous, highly attractive, saxicolous crustose lichen, readily recognised by its vivid scarlet apothecia. It has no confusing species in that the only other known Tasmanian saxicolous taxa with red, K+ magenta fruiting bodies are inevitably species of *Caloplaca* and so differ by having *Teloschistes*-type asci, mostly polaribilocular ascopores and a frequently persistent and distinct zeorine or lecanorine apothecial margin.

The new species is very similar to the corticolous *R. laeta* (Stirt.) Kalb and, in the past, all saxicolous collections now named *R. greeniana* were subsumed under that species. That the saxicolous material might represent a distinct taxon has been a matter of conjecture (and at times spirited discussion) in the past (Elix & Kantvilas 2005), and at that time (*loc. cit.*), I advocated that no consistent differences, morphological, anatomical or chemical, could be observed that might underpin the taxonomic separation of saxicolous and corticolous populations. An opportunity to collect and study many more specimens has changed my opinion. The character that unequivocally separates the two species, other than substratum, is thallus morphology: when growing in ideal situations, the thallus of *R. greeniana* is distinctly isidiate (Fig. 3A). In more exposed situations, the thallus becomes increasingly abraded and overgrown by cyanobacterial and other growths, the isidia are fractured or eroded away, and the thallus is better described as papillate or verruculose (Fig. 3B). However, careful inspection of such specimens will usually reveal at least some isidia or at least short, cylindrical projections from the thallus surface. The availability of only such abraded material for previous studies (Elix & Kantvilas 2005) meant that this important character was overlooked.

There are few other consistent differences between the two taxa. The dimensions of apothecial tissues and ascospores are essentially the same. Conidia were found only in one specimen of *R. greeniana* and were significantly longer than the 10–20 µm long conidia recorded for *R. laeta* (Elix & Kantvilas 2005), but the rareness of pycnidia meant that these dimensions could not be confirmed. Chemical composition is also equivocal, although no substances have been detected in any specimen of *R. greeniana*, whereas *R. laeta* may sometimes contain lichesterinic and protolichesterinic acids.

Specimens examined: **Tasmania.** Wombat Moor, 42°41'S 146°37'E, 1050 m alt., 13.x.1981, *G. Kantvilas 767/81* (BM, HO); Ridge E of Ouse R, 7 km SE of Lake Augusta, 41°54'S 146°37'E, 1140 m alt., 7.xii.1993, *G. Kantvilas 212/93 & J.A. Elix* (HO); St Pauls Dome, 41°46'S 147°50'E, 23.xi.1997, *G. Kantvilas 249/97* (HO); M. Road, c. 1 km E of Goat Hills,

Figure 4. *Ramboldia greeniana* anatomy. A: asci, paraphyses and ascopores, with amyloid tissues stippled. B: conidia. Scale = 10 µm.



42°19'S 147°54'E, 240 m alt., 7.i.1997, *G. Kantvilas 19/97* (HO); summit of Mt St John, 41°47'S 148°05'E, 778 m alt., 31.vii.1999, *G. Kantvilas 316/99* (HO); Mt Foster, 41°44'S 147°53'E, 1010 m alt., 17.v.1999, *G. Kantvilas 198/99* (HO); western slape of Table Mtn, 42°14'S 147°08'E, 1050 m alt., 6.x.2001, *G. Kantvilas 924/01* (HO); Paradise Gorge, 42°33'S 147°50'E, 150 m alt., 2.vi.2011, *G. Kantvilas 196/11, 202/11* (HO); Three Thumbs, 42°36'S 147°52'E, 540 m alt., 2.vii.2012, *G. Kantvilas 308/12* (HO); Woods Quoin summit, 42°17'S 147°06'E, 925 m alt., 5.v.2013, *G. Kantvilas 52/13* (HO); summit of Brown Mtn, 42°36'S 147°32'E, 790 m alt., 16.v.2015, *G. Kantvilas 180/15* (HO); Clemes Peak, 43°04'S 147°57'E, 410 m alt., 21.vi.2015, *G. K1antvilas 189/15* (HO); Last Falls Reserve, 42°03'S 147°53'E, 540 m alt., 12.viii.2015, *G. Kantvilas 268/15* (HO); Mother Brawns Bannet summit, 42°48'S 147°44'E, 405 m alt., 23.viii.2015, *G. Kantvilas 280/15* (HO); Rascabarough, Rascabaraugh Road 2, 42°04'S 146°29'E, 880 m alt., *G. Kantvilas 449/15* (CANB, HO); Gawan Brae, S af Circular Marsh, 42°00'S 146°29'E, 900 m alt., 10.xii.2015, *G. Kantvilas 448/15 & J. Jarman* (CANB, HO, NY).

Ramboldia stuartii (Hampe) Kantvilas & Elix, *Bryologist* 97: 299 (1994).

= *Lecidea subsericea* Zahlbr., *Denkschr. Akad. Wiss. Wien math-naturwiss. Kl.* 104: 308 (1941). Type: New Zealand, Nelson, Lead Hills, on dead twigs of *Dacrydium colensoi*, *J.S. Thomson T1988 [ZA 664]* (holotype W; isotypes BM!, CHR!, OTA).

The isotype specimens examined contain fragments of an unidentified species of *Lecidella* in addition to the *Ramboldia*. However, the original description (Zahlbruckner 1941) refers unequivocally to *R. stuartii*, citing such characteristic features as the K+ violet inclusions in the hypothecium that signify the presence of diagnostic hypothamnolic acid.

Acknowledgements

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Corrections to *Muelleria* 34, Brown (2015a) pp. 15–21 and Brown (2015b) pp. 23–46

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Corrections

In Brown (2015a, b), some collection numbers were incorrectly cited or numbers transposed at the production stage.

In Brown (2015a), under *Lachnagrostis adamsonii* subsp. *limosa* A.J.Br. subsp. nov., in 'Selected specimens examined' (p21); the collection number *A.J. Brown 1360* should be deleted. Also, under *Lachnagrostis adamsonii* subsp. *adamsonii*, it should be 'Blackgate Rd' not 'Black Rock Rd', as per ... 'easement opposite Blackgate Rd, Breamlea, 23.ii.2004, *A.J. Brown 1729* (MEL)'.

In Brown (2015b), Appendix 1: p45, under *Agrostis barbuligera* var. *barbuligera*, the collectors' number *'L. Smook 1081A'* should be *'L. Smook 1080A'* (PRE513672). Also, the collectors' number under *Agrostis eriantha*, SOUTH AFRICA: *'N.J. Devenish 3843'* should be *'N.J. Devenish 1843'* (PRE664945).

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Brown, A.J. (2015b). A morphological search for *Lachnagrostis* among the South African *Agrostis* and *Polypogon* (Poaceae). *Muellerio* 34: 23-46.

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